W K Hodges

POTOMAC RIVER ENVIRONMENTAL FLOW-BY STUDY

Submitted to
The United States Army Corps of Engineers
in
Fulfillment of the Requirements of
Article 2.C of
The Potomac River Low Flow Allocation Agreement

Prepared By:

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Maryland Department of Natural Resources

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CHAPTER I

RECOMMENDATIONS FOR AN ENVIRONMENTAL FLOW-BY AND EXECUTIVE SUMMARY

I. Recommendations for an Environmental Flow-by and Executive Summary

A. Environmental Flow-by Recommendations

The primary "charge" to the State of Maryland in conducting the Environmental Flow-by Study was to assess the environmental effects of various increments of low flow and make recommendations to the U.S. Army Corps of Engineers for the establishment of "any amount needed for flow in the Potomac River downstream from the Little Falls dam for the purpose of maintaining environmental conditions" (See Chapters II and V and Appendix D, Potomac River Low Flow Allocation Agreement). To specifically and adequately address the study "charge" in the context of available water management alternatives, the environmental flow-by recommendation will be presented as two separate recommendations:

RECOMMENDATION #1: Establish a minimum daily environmental flow-by of 100 million gallons a day (mgd) below Little Falls dam. Recommendation #1 will form the basis for implementing the Potomac River Low Flow Allocation AGreement formula.

RECOMMENDATION #2: At a calculated flow of 500 mgd just above the Great Falls intake, begin shifting Aqueduct withdrawals to the Little Falls dam intake to maintain at least 100 mgd plus the Washington Aqueduct's allocation up to 200 mgd between Great Falls and Little Falls dam.

A broad spectrum of Potomac River resources and uses including, the fishery, macroinvertebrates, wildlife, recreation and water quality were analyzed in an effort to gain an understanding of the potential impacts associated with low river flows from zero to 1100 mgd. The impacts of historical low river flow on non-fishery resources and uses, such as boating or wildlife were found to be negligible or of a short term nature, thus are only of minor concern. The fishery resource will be most affected by low river flow.

In establishing the recommended 100 mgd flow-by below Little Falls dam, a few of the factors taken into consideration were:

1. Practical water management realities including historical flow frequency, water supply demand, and water use restriction capabilities, presently limit the amount of water available for a minimum environmental flow-by. A daily average flow below Little Falls dam of 100 mgd is nearly the limit of what the current system can provide during extreme drought conditions.

2. The integrity of the fishery can be protected by establishing a flow-by as a daily minimum rather than a weekly average minimum. In addition, the current low flow allocation formula is calculated on a daily basis.

3. The area of potential impact extends approximately one mile from Little Falls dam to Little Falls -- however, the only area of significant concern is a small 22 acre backwater (See Zone 3 fishery discussion in Chapter V.)

4. Of all areas of the Potomac analyzed, the section from Little Falls dam to Little Falls was found to contain the poorest fishery habitat (averaging six to ten times less habitat available per 1,000 feet than is found above the dam) and is the least accessible for fishing.

5. The species of most concern (and most adversely affected) in the fluvial area below the dam is the juvenile life stage of the smallmouth bass -- estimated to number only 3500 juveniles (0 to 3 years of age) in any given year under average flow conditions in the 22 acre backwater.

6. Low flows at the level and duration necessary for a significant decline in the juvenile smallmouth bass population below the dam would be expected to occur only about once in twenty years. It is estimated that the smallmouth bass population would fully recover in approximately 4 years.

After weighing the above factors in terms of existing water supply needs and natural flow frequencies, it was determined that a minimum daily environmental flow-by of 100 mgd is reasonable and will be sufficient to protect the integrity of the fishery below Little Falls dam.

A considerably different environmental and use situation exists above Little Falls dam -- necessitating formulation of Recommendation #2. A very productive and highly used fishery exists between Great Falls and Little Falls dam. Even at the lowest flows, there is six to ten times more ideal habitat available per 1000 feet of stream above the dam than below the dam. The gross wetted area per 1000 feet of much of the river above Little Falls dam is more than two times that found below the dam. In addition, thousands of fishermen converge on the area each year as a result of easy access and the challenges offered by a varied and productive fishery.

Based on analysis of low flow related impacts in relation to water management opportunities, an effort should be made to maintain a minimum 100 mgd plus the Washington Aqueduct withdrawals up to 200 mgd between Great Falls and Little Falls dam. Washington Aqueduct withdrawals are usually at or near 200 mgd during late summer and early fall. The integrity of the fishery can be maintained at such a flow that lasts no longer than the recorded historical duration for that flow. By gradually shifting Aqueduct withdrawals to the Little Falls dam Intake when 500 mgd is observed just above the Great Falls intake, up to an additional 200 mgd would be available for environmental purposes down to the dam. Although pumping costs at Little Falls are high (approximately $8,000 a day) such pumping for environmental purposes would only occur on estimated average of one day in seven years.

B. Future Environmental Considerations

RECOMMENDATION: Upon completion and operation of Bloomington Reservoir, establish a monthly flow schedule, based on existing information regarding water management opportunities, that will optimize in-stream values while meeting water supply needs.

Bloomington Reservoir was constructed for such multiple purposes as water quality control in the North Branch of the Potomac and enhancement of water storage/supply capabilities. According to one management strategy developed by ICPRB CO-OP, operation of Bloomington Reservoir could mean that with "year 2000 demands" and water use restrictions in place, an additional 70 mgd could be made available on a daily basis for environmental concerns, bringing the total environmental flow to 170 mgd. If operated on a weekly average basis a environmental flow of 200 mgd (weekly average) could be maintained. Since there is flexibility in releases from the Bloomington Reservoir, a monthly flow schedule could be maintained in an effort to manage and optimize the fishery environment.

A plan development permit has been issued by the Maryland Water Resources Administration for the proposed construction of Little Seneca Reservoir. ICPRB CO-OP indicates that under certain management strategies, Little Seneca, if constructed and operated on a regional basis, could mean that, with year 2000 demands and water use restrictions in place, an additional 130 mgd could be made available (beyond that which is possible with Bloomington) to meet environmental management objectives. This could bring the total environmental management flow to 300 mgd.

Designation of a specific monthly optimization flow management schedule is beyond the protection oriented scope of this study. As Bloomington becomes fully operational, a monthly flow schedule is recommended to optimize in-stream and out-of-stream needs to the extent practically possible.

Establishment of a monthly flow schedule could be based on:

1) Additional in-depth analysis and refinement of existing data.

2) "Trade-off" considerations between fish species and life stages as well as among other in-stream values and uses (The decline in low flow associated habitat availability for certain life stages of some key fish species below Little Falls dam is off-set by a corresponding increase in availability of habitat above the dam during low flows -- See Chapter VII).

3) Collection of additional needed information on fish life stage requirements.

4) Refinement of system management modeling capabilities.

5) Other management and institutional considerations that may become evident as efforts are made to fully manage the Potomac.

CHAPTER II

INTRODUCTION

II. Introduction

In 1978, the Potomac River Low Flow Allocation Agreement was developed to provide an interjurisdictional mechanism for allocating water among the various Potomac water suppliers during periods of critical low flow. Signatories to the "Agreement" include the United States of America acting by the Secretary of the Army through the Chief of Engineers, the State of Maryland acting by the Governor and the Secretary of the Department of Natural Resources, the Commonwealth of Virginia acting by the Governor and the Chairman of the State Water Control Board, the District of Columbia acting by its Mayor, the Washington Suburban Sanitary Commission acting by its chairman and the Fairfax County Water Authority acting by its chairman. The portion of the Potomac covered by the "Agreement" extends from Little Falls dam to the farthest upstream limit of the pool of water behind the Chesapeake and Ohio Canal Company rubble dam at Seneca, Maryland.

The need for maintaining sufficient water in the Potomac to protect in-stream values during periods of critical natural low flow is established in Article 2.C of the "Agreement" (See Appendix D). Article 2.C reads as follows:

> "Whenever the Restriction Stage [total daily withdrawal is equal to or greater than eighty percent of total daily flow] or the Emergency Stage [projected total daily withdrawal in excess of daily flow] is in effect, the Aqueduct shall daily calculate and advise each user, and the Moderator, of each user's allocated fair share of the water available from the subject portion of the Potomac River in accordance with this Section C. In calculating the amount of water available for allocation, the Aqueduct will determine, in consultation with the parties, and based upon then current conditions and information, <u>any amount needed for flow in the Potomac River downstream from the Little Falls dam for the purpose of maintaining environmental conditions (environmental flow-by)</u>*, and shall balance such need against essential human, industrial and domestic requirements for water. The Aqueduct's determination shall be based upon the data and shall give substantial weight to conclusions for environmental flow-by submitted by the State [of Maryland]."

In July of 1978, the U.S. Army Corps of Engineers developed a "Memorandum of Intent" for clarification of the environmental flow-by/allocation formula portion of the "Agreement" (See Appendix D). The "Memorandum of Intent" stated that "the Washington Aqueduct will include along with the amount of water withdrawn from the subject portion of the river that amount designated as the environmental flow-

*Emphasis Added

by. Thus, when the Washington Aqueduct determines that the amount withdrawn, combined with the environmental flow-by amount, is equal to or greater than eighty (80) percent of the total daily flow, the Restriction Stage will be put into effect and allocation will begin."

It is Article 2.C that establishes the primary "charge" and objective of the environmental flow-by study conducted by the State of Maryland -- that is, the development of "conclusions" (environmental flow-by recommendations and impact associated with low flows) for the establishment of an "amount needed for flow in the Potomac River downstream from Little Falls dam for the purpose of maintaining environmental conditions." Beyond the primary study "charge" and objective, data collection and analysis was expanded in an effort to make a thorough examination of low flow effects on a broad range of environmental values and recreational activities from Seneca Pool to Little Falls, including a portion of the extreme upper estuary. Expansion of the study scope provided an information base that will enable the development of future management alternatives for the Potomac beyond the immediate and necessary need for the establishment of a flow-by below Little Falls dam.

During the early phase of study design it was determined that only the lower fluvial portion of the Potomac (between Little Falls and Seneca Pool) would be measurably affected by potential low flows and water withdrawals. Previous federal and state modeling efforts, as well as, some modeling done in conjunction with the flow-by study, indicate that the tidal Potomac Estuary is not adversely affected by cyclic low flow conditions. Tidal influence, estuary size, and the natural break-down of nutrients and BOD were found to have a far greater impact on the tidal Potomac than low freshwater in flows. Thus, the data collection and analysis focused on the fluvial Potomac. See Chapter VI, Section B, for a quantitative discussion of the focus of the flow-by study in relation to water quality in the tidal Potomac.

Primary data collection for the study was conducted in the summers of 1978 and 1980 during periods of low flow. Velocity, depth and substrate data was obtained at various locations for fishery analysis utilizing the U.S. Fish and Wildlife Services Instream Flow Group (IFG) Model (See Chapter IV). The model, developed initially for use on small western streams, predicts changes in ideal habitat availability per 1,000 feet of stream for various fish species. The model proved to be a useful tool for analyzing relative changes in habitat availability at various flows, however, its application was limited by the following constrictions:

1. The model would not provide results below flows of 300 mgd with any acceptable degree of confidence.

2. The model had never been applied to a stream as large or complex as the Potomac -- thus data collection was hampered, certain data collected had to be discarded or greatly adjusted because of lack of uniformity, and the amount of data collected was insufficient for thorough analysis of all habitat types.

3. Necessary data is not available for eastern streams to determine the full significance of square feet of available ideal habitat per 1,000 feet -- that is, whether or not 100,000 sq. ft. of available habitat is in fact excellent habitat or only marginal habitat when compared to some regional standard of suitability.

4. The model does not provide a direct indication of changes in sub-ideal or marginal habitat availability nor does it establish a direct relationship to changes in water quality.

Beyond the IFG model methodology, secondary data was collected and analyzed for flow related impacts on recreation, wildlife, macroinvertebrates, and water quality.

The document that follows is organized first, to familiarize the reader with the study portion of the river and data collection procedures, and second, to provide an understanding of low-flow associated effects on the fluvial and upper estuary portion of the Potomac. The fishery section of Chapter V is divided into two segments, impacts below Little Falls dam and impacts above Little Falls dam, to facilitate flow-by recommendations that specifically address the study "charge." The "Study Area Map" in the back cover and the "Summary Impact Matrix" should be referred to for orientation and comparison of low flow impacts.

The study was developed to establish a minimum acceptable environmental flow-by in what is essentially an unregulated river. It is recognized that with the completion of the Bloomington Reservoir and the pending development of the Little Seneca Reservoir, more water will be available in the Potomac for both environmental and water supply purposes (See Chapter VII). Future options may exist for managing the Potomac in an effort to optimize in-stream values. Specific recommendations for optimization management, while recognized in this document, are beyond the charge and scope of the environmental flow-by study and should be addressed in the future.

CHAPTER III

DESCRIPTION OF THE FLUVIAL POTOMAC RIVER

III. Description of the Fluvial Potomac River

A. Physical

The Potomac River drains 11,560 square miles of the Middle Atlantic Coastal Region. The river is a free flowing stream for 186 miles from its headwaters in the Appalachian Mountains to Little Falls near Washington D.C.; there becoming an estuary extending 114 miles to the Chesapeake Bay.

The Upper Potomac River watershed (see figure 3-1) is a mountainous region where the river flows through long flat reaches, occasionally interrupted by rapids. In the Appalachian Mountains, the river developed a trellised drainage pattern along lines of least resistance. There the river flows in a north-east direction along belts of weak rock, turning at right angles to cut through ridges. From Hancock, the river meanders in a south-east direction following a dendritic drainage pattern until it reaches Washington D.C.

The study portion of the river, from Seneca Pool to Little Falls, is entirely within the Piedmont Province, which is characterized by rolling terrain (see figures 3-2 and 3-3). Elevations of the river bed range from 180 feet a.s.l. (above sea level) to about 20 feet a.s.l. at Little Falls. Above Blockhouse Falls, located about one mile down stream from Seneca Pool, (see figure 3-4) the gradient averages 4.0 feet/mile (Parker, et al, 1907). From Blockhouse Falls to Little Falls, the river contains many falls and rapids, and has an average gradient of 8.5 feet/mile.

The regional geology through which the Potomac River flows is illustriated in figure 3-5. At Seneca Pool, the river cuts through Triassic sandstones and shales. Between Seneca Breaks and Little Falls, the river slices through granitic and gneissic rocks of Precambrian and Lower Paleozoic Age. In some places a veneer of Pleistocene and recent alluvial sediment has been deposited along the river banks and on some of the river's small islands. Bottom composition appears to consist primarily of rock, gravel and coarse sand with accumulations of fine materials in low velocity flow areas (Cloos, et al, 1964).

Most of the bedrock in the Piedmont is covered with a regolith. Water is stored in, and moves through, both the regolith and fractures in the underlying rock, providing base flow to parts of the Potomac River and its tributaries.

B. Hydrological

Stream flow in the Potomac River and its tributaries is provided by a combination of direct runoff from the land surface and subsurface discharge from groundwater storage. During periods between storms, river flow is provided from water stored in the channel and from groundwater base flow (Trainer, 1975).

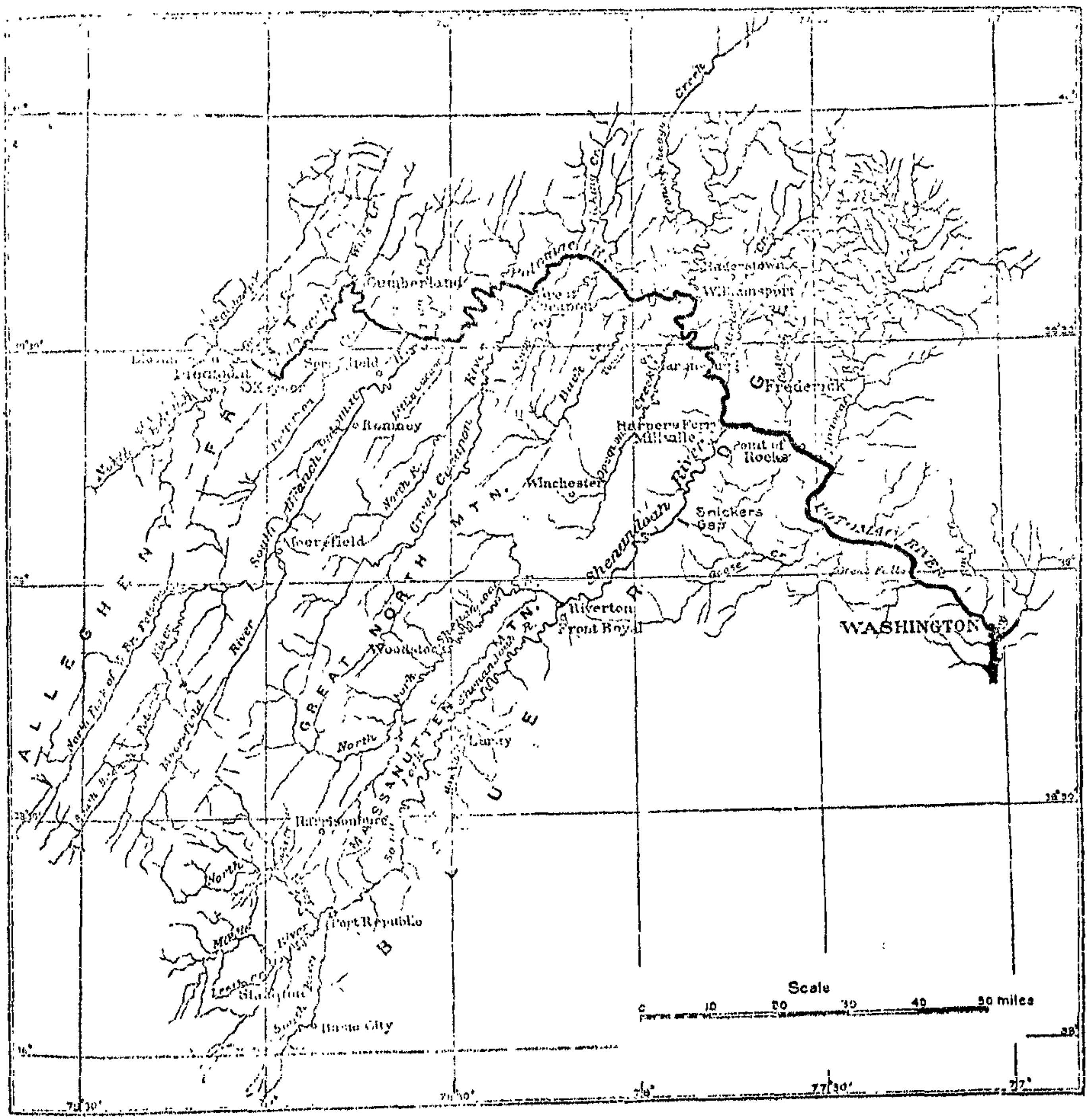


Figure 3-1 Map of the Potomac River Drainage Basin
(adapted from Parker, et al, 1907)

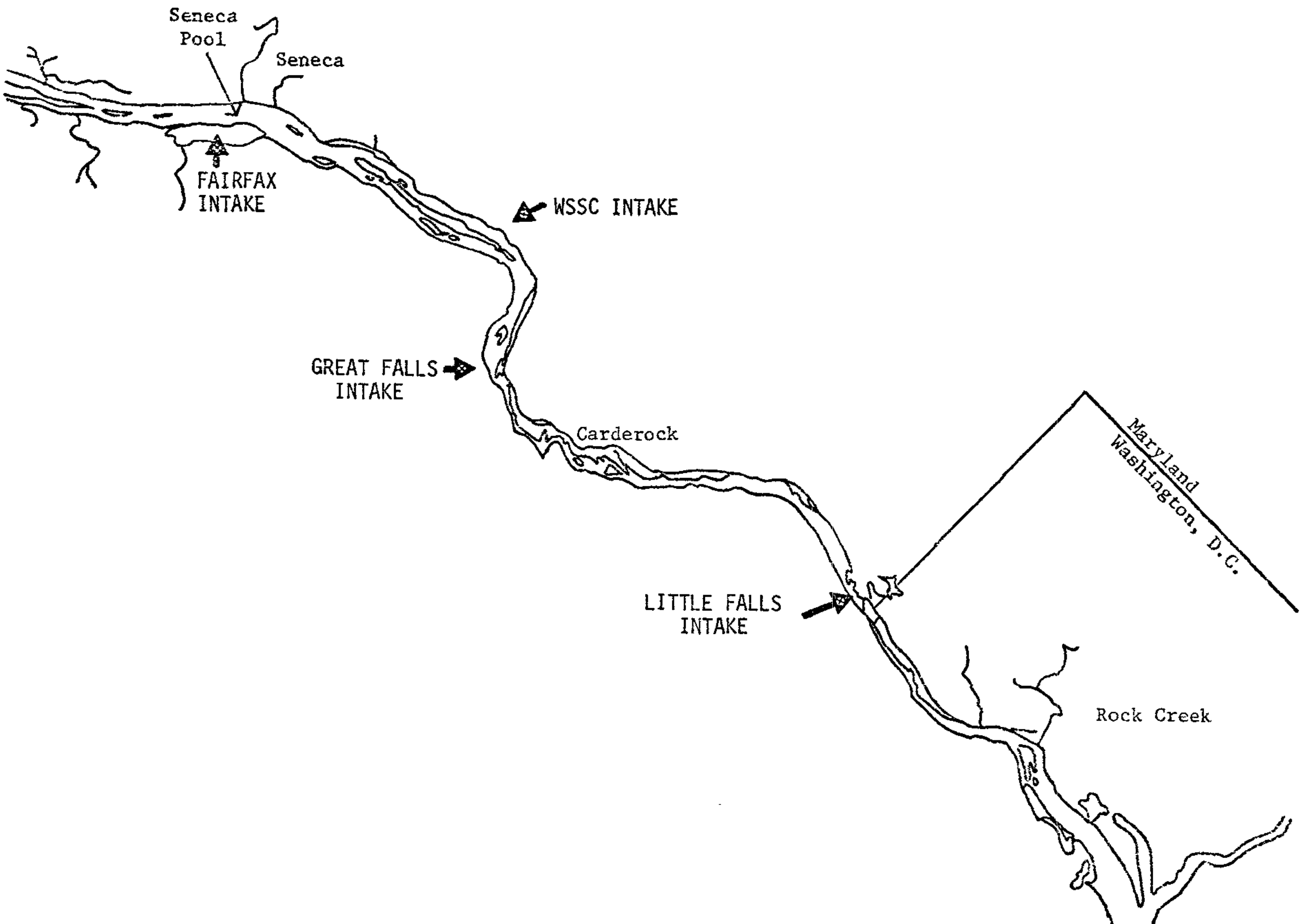


Figure 3-2 Map of Study Area Showing Intake Locations

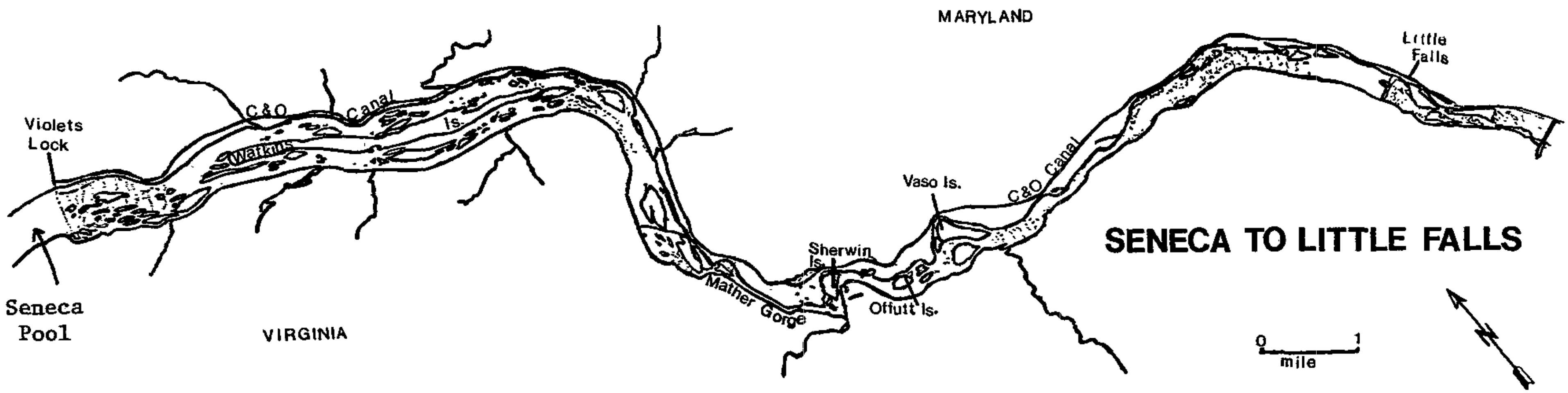


Figure 3-3 Map of Study Area

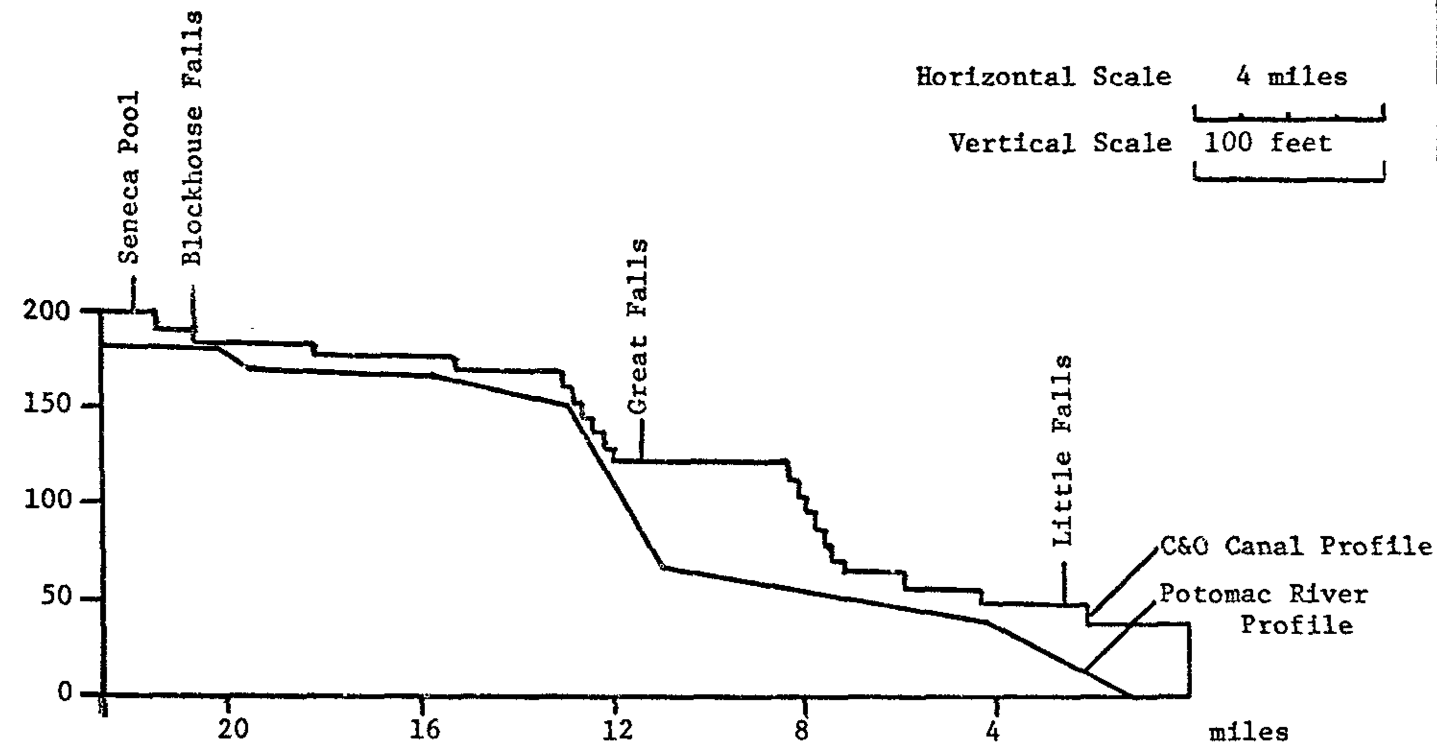


Figure 3-4 Profile of the Potomac River from Seneca Creek to Little Falls (adapted from Parker, et al, 1907)

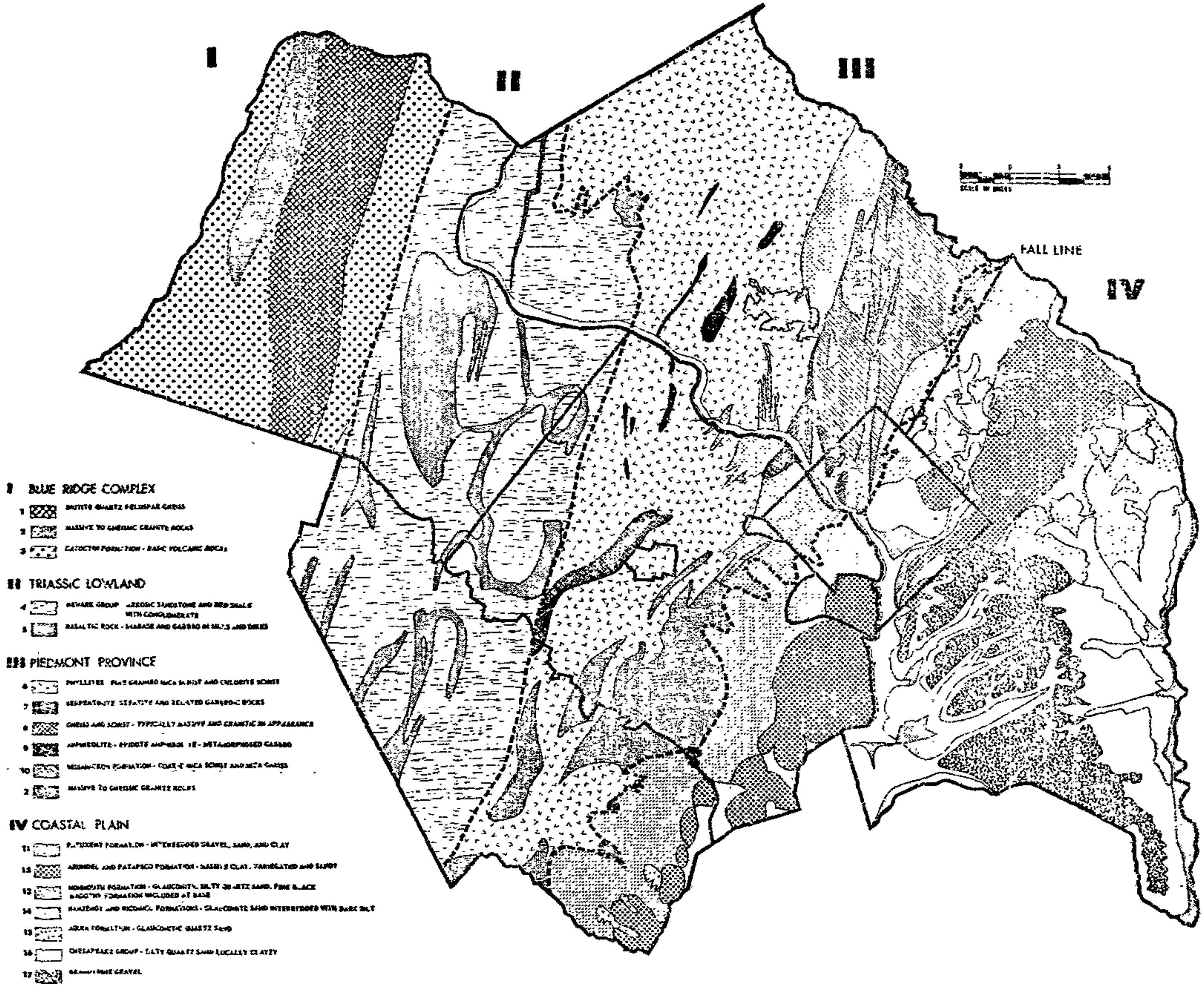


Figure 3-5 Generalized Geology of the Lower Potomac River Basin (adapted from The Comprehensive Water Supply and Sewerage Plan for Montgomery County; June 1979)

The amount of water in the river depends upon the amount of precipitation that either enters the ground or becomes runoff. Typically snow melt and winter rain provide high runoff and a large part of the groundwater recharge. Both groundwater base flow and runoff greatly diminish during summer because of higher rates of evaporation and transpiration, leading to noticable declines in river flow.

Decline in flow is especially conspicuous during extended dry periods when groundwater provides almost all of the river flow as illustrated in Figure 3-6. As the groundwater reserve becomes depleted, the amount of water available for base flow decreases. If the water table becomes low enough, water may seep out of the channel into the ground, further reducing river flow.

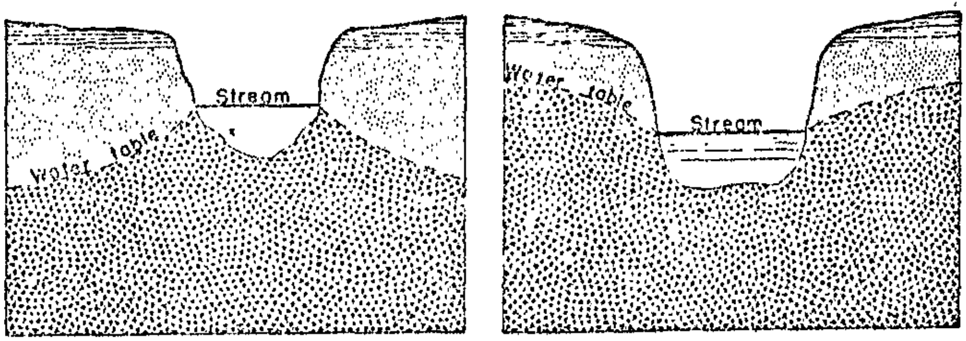
Flows in the Potomac River fluctuate greatly depending upon the amount of precipitation that falls in the river basin. Precipitation varies for different parts of the watershed within the study area, averaging between 40 and 45 inches per year. Figure 3-7 indicates average rainfall in the Maryland portion of the Potomac River watershed.

The average adjusted River flow at Little Falls is 7,358 mgd (million gallons per day)*. A maximum adjusted recorded daily flow of 315,564 mgd occurred on March 19, 1936 and a minimum flow of 394 mgd*, occurred on September 10, 1966. The observed flow at Little Falls on September 9, 1966 was only 78 mgd. As illustrated in Figure 3-8, the maximum mean yearly flow was 13,824 mgd in 1972 and the lowest mean yearly flow was 3,549 mgd in 1969 (Walker, 1971).

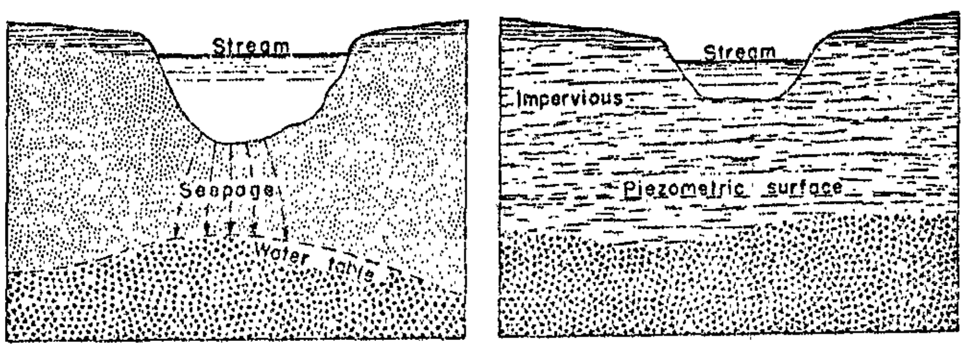
Low flows can be described by their magnitude, duration and frequency. Table 3-1 shows the relationship between these properties for Little Falls Dam on the Potomac River near Washington D.C.

The Potomac River is the only major surface source of potential, additional, non-saline water supply available (without resorting to massive inter-basin transfer), for the Washington Metropolitan Area. Average annual regional withdrawals per year ranged from 187 mgd in 1960 to 325 mgd in 1980. As indicated in figure 3-9, the general trend has been one of steadily increasing annual regional withdrawals per year since the 1960's. During each year, maximum usage usually occurs between June and September, (see Figure 3-10) with monthly averages ranging from 320 to 390 mgd. Minimum regional withdrawals usually take place between November and March and range from a monthly average of 280 to 310 mgd.

*Total flow = flow observed at Little Falls plus adjustments for diversions and municipal withdrawals.



Influent stream on the left loses water to the aquifer; effluent stream on the right gains water from the aquifer because water table is above the stream bed.



Stream on the left flows only following periods of surface runoff, but is dry during droughts. Stream on the right is isolated hydraulically from artesian aquifer below it.

Figure 3-6 The Effect of the Water Table on Base Flow (adapted from Johnson Division, Universal Oil Products Co., 1972)

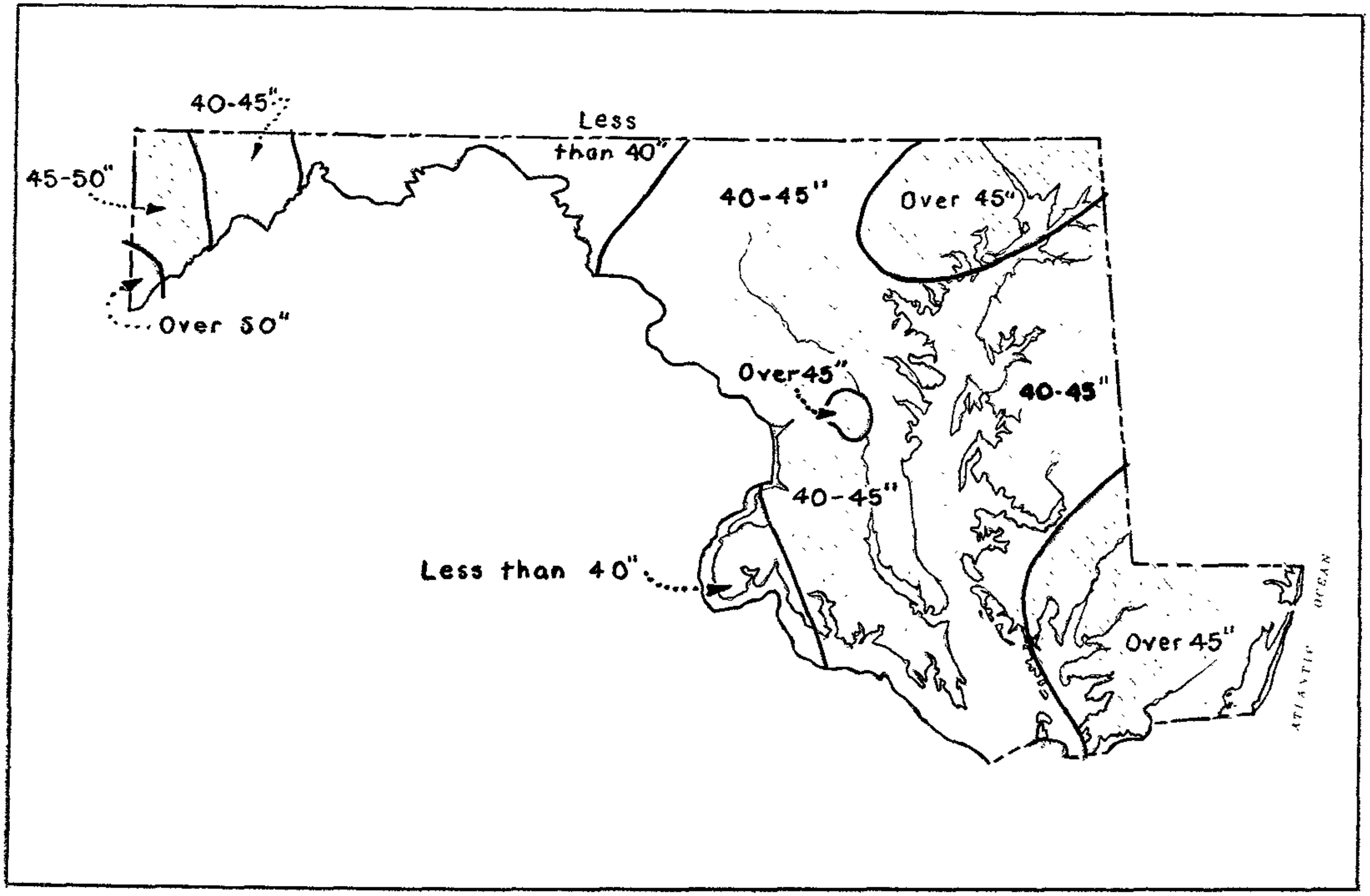


Figure 3-7 The Average Yearly Precipitation in Maryland
(adapted from Walker, 1970)

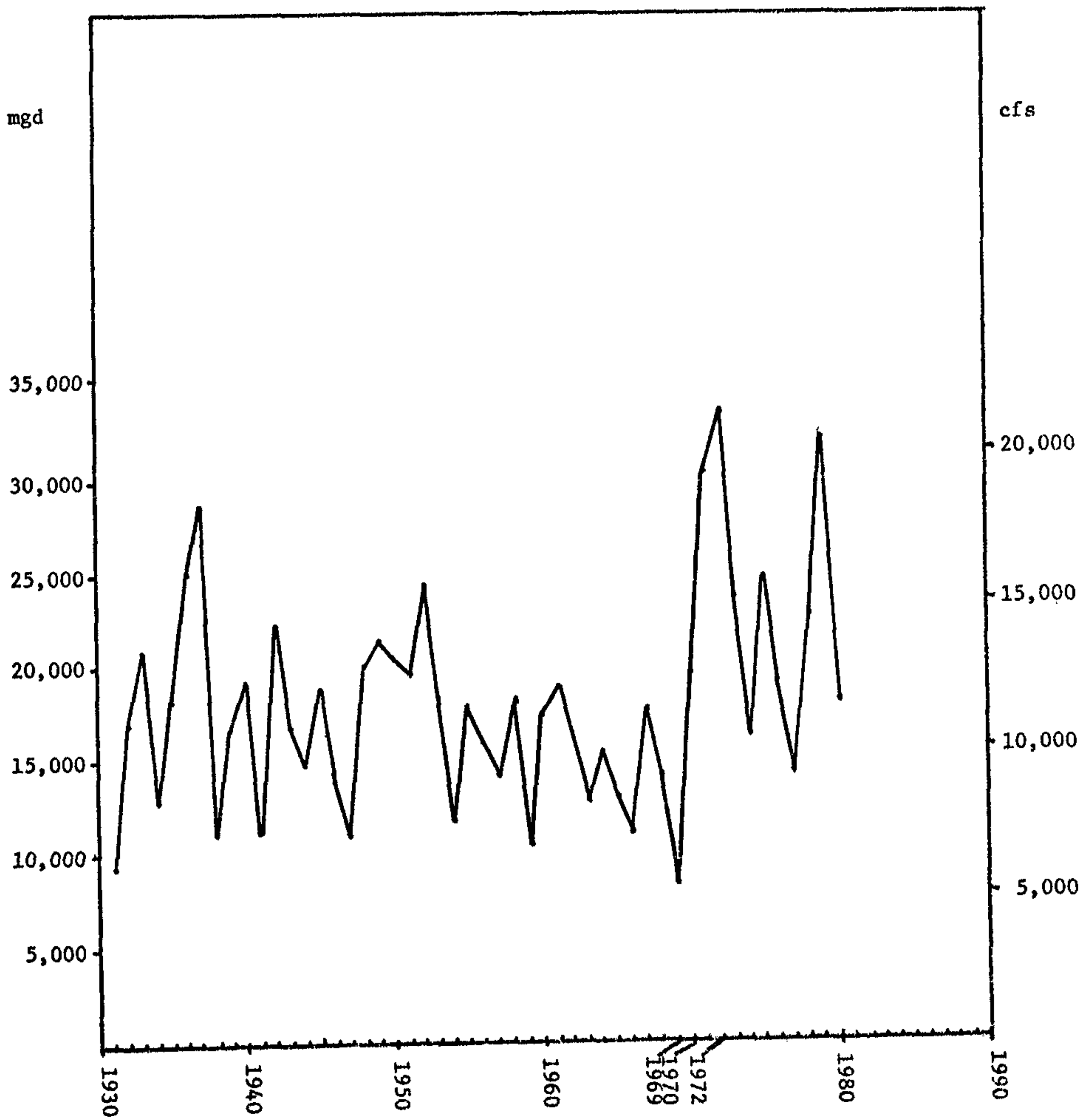


Figure 3-8 Average Yearly Discharge, per Calendar Year, of the Potomac River at Little Falls Dam, near Washington, D.C. (data from the U.S. Geological Survey, 1964, 1981)

Magnitude and Frequency of Annual Low Flow

(Based on Observed Flow during the Period Apr. 1, 1930, to Mar. 31, 1967)

Annual Minimum	Discharge, in mgd*, for Indicated Recurrence Interval, in Years				
	2-year	5-year	10-year	20-year	50-year
7-day	859	506	362	266	-
14-day	911	543	395	295	-
30-day	1,008	635	492	397	-
60-day	1,273	762	574	453	-
90-day	1,499	898	691	556	-
120-day	1,796	1,111	853	691	-

Magnitude and Frequency of Annual Low Flow

(Based on Adjusted Flow during the Period Apr. 1, 1930, to Mar. 31, 1967)

Annual Minimum	Discharge, in mgd*, for Indicated Recurrence Interval, in Years				
	2-year	5-year	10-year	20-year	50-year
7-day	1,047	743	614	523	-
14-day	1,098	782	646	556	-
30-day	1,121	866	730	633	-
60-day	1,486	995	814	691	-
90-day	1,718	1,124	917	782	-
120-day	2,009	1,330	1,079	904	-

* 0.646 mgd = 1 cfs (cubic feet per second)

Table 3-1 Magnitude and Frequency of Annual Low Flows at Little Falls Dam Gage near Washington, D.C. (adapted from Walker, 1971)

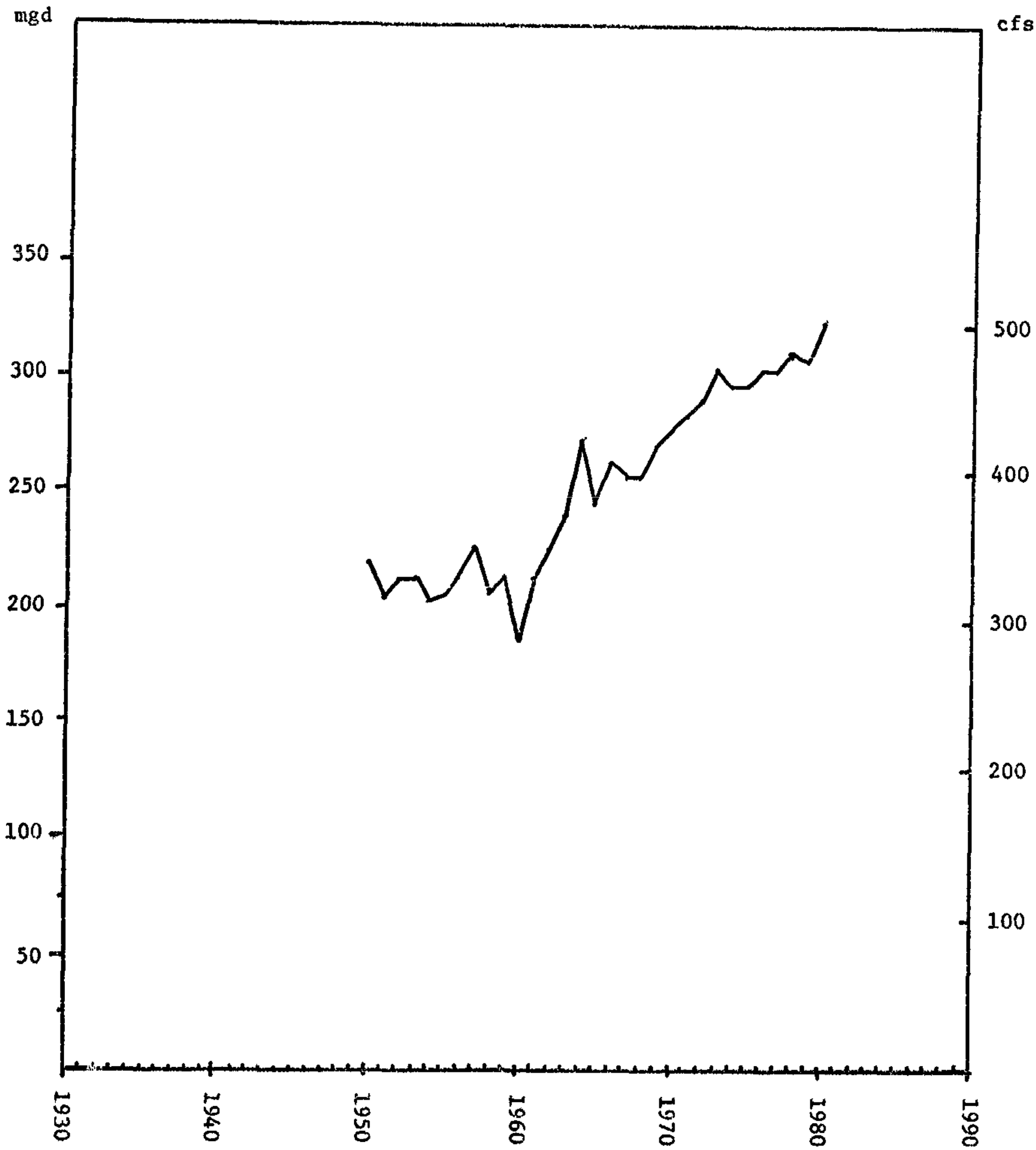


Figure 3-9 Average Yearly Withdrawals, per Calendar Year, of the Potomac River prior to Little Falls Dam, near Washington, D.C. (data from the U.S. Geological Survey, 1964, 1981)

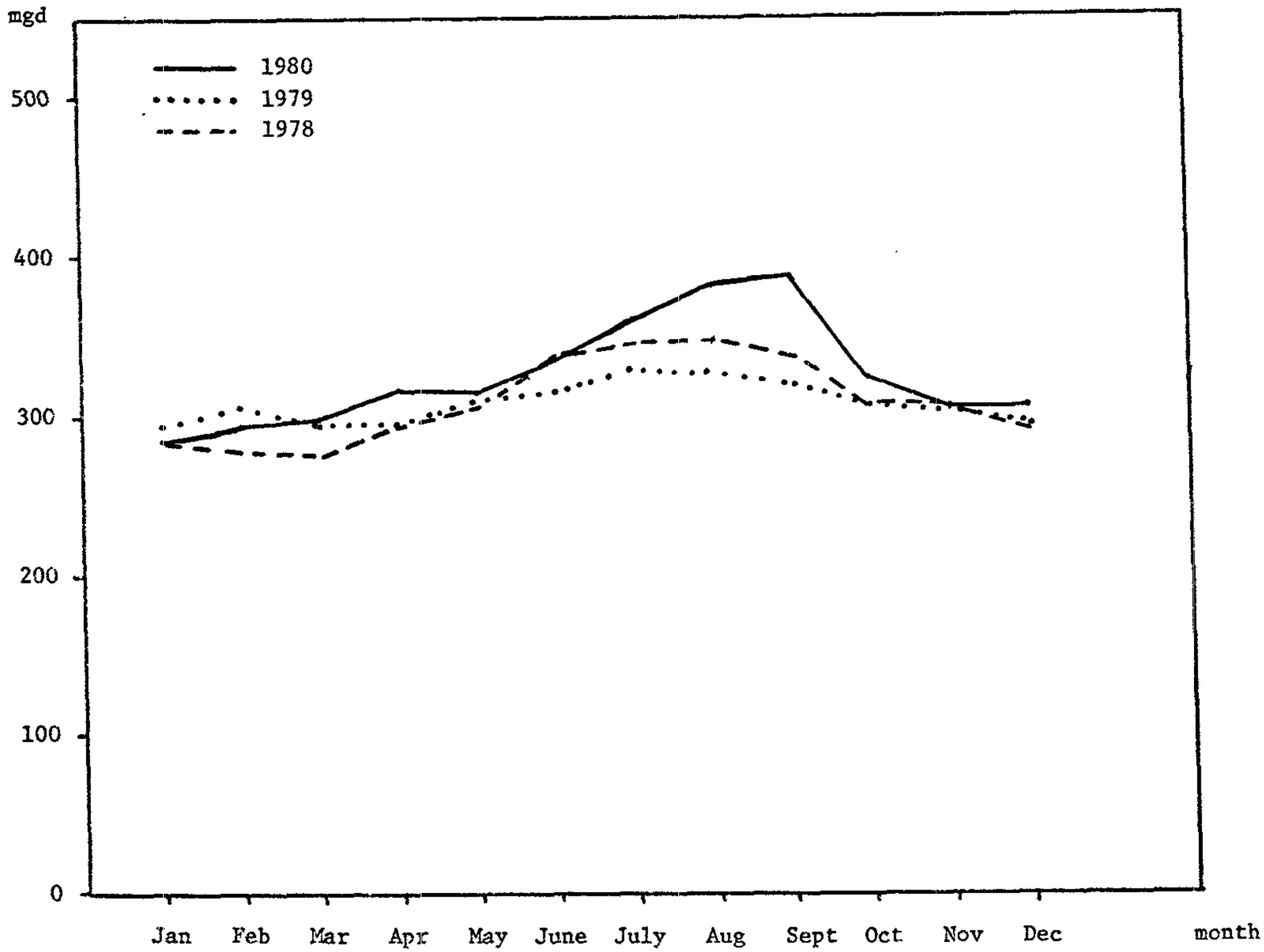


Figure 3-10 Graph of Average Withdrawals from Study Portion of the Potomac per Month from January 1978 to December 1980 (Data from U.S. Army Corps of Engineers, Washington Aqueduct Division, 1978-1980)

The cyclic increases and decreases in water use contrast the yearly occurrences of high and low river flows. Peak flows usually occur between February and early May (see figure 3-11), whereas minimum flows tend to be between June and October. As a result of tropical storms and hurricanes, there may occasionally be high flows in September or October. During periods of unusually low flow, such as occurred in September 1966, withdrawals could potentially equal or exceed total river flow, as indicated in figure 3-12.

C. Biological

The Potomac River supports a large and diverse biologic community. The number and variety of species within the community is far too great to permit a description of all species within this report. However, those species and biotic types which inhabit the study area and which have been deemed to be important, conspicuous, or dominant, or which were specifically observed and identified in the course of field investigation, are described herein. For the purpose of this report, the biota are divided into the following categories; Wildlife, Fish, Aquatic Vegetation, Microbiota, and Macroinvertebrates.

1. Wildlife

For the purpose of this study, the wild animals and birds living within the sphere of the Potomac ecosystem from Seneca Pool to the upper estuary, have been divided into three groups. These groups, which in part reflect the animals dependence on the flowing river, are aquatic dependent animals, partially aquatic dependent animals and non-aquatic dependent animals.

An aquatic dependent animal is defined herein as one which lives and feeds in the river most of the time. Aquatic dependent animals are totally dependent upon the river for survival during at least part of their life cycle. In the study area, aquatic dependent mammals include the rare river otter and the more common beaver and muskrat. These species spend much of their time in the water and partially depend upon the river as a source of food. Aquatic reptiles, including snapping turtle, mud turtle, spotted turtle, painted turtle, red bellied turtle and the northern water snake, are common throughout the study area and frequent both the water and the near shore. Aquatic amphibians which primarily inhabit the overflow pools of the Potomac floodplain, include the two-lined salamander, marbled salamander, spotted salamander, dusty salamander, red-backed salamander, shiney salamander, mud salamander, green frogs, leopard frogs, bullfrog and red spotted newt. Green treefrogs, spring peepers, northern cricket frogs, pickerel frogs, eastern wood frogs and American toads also depend upon the overflow

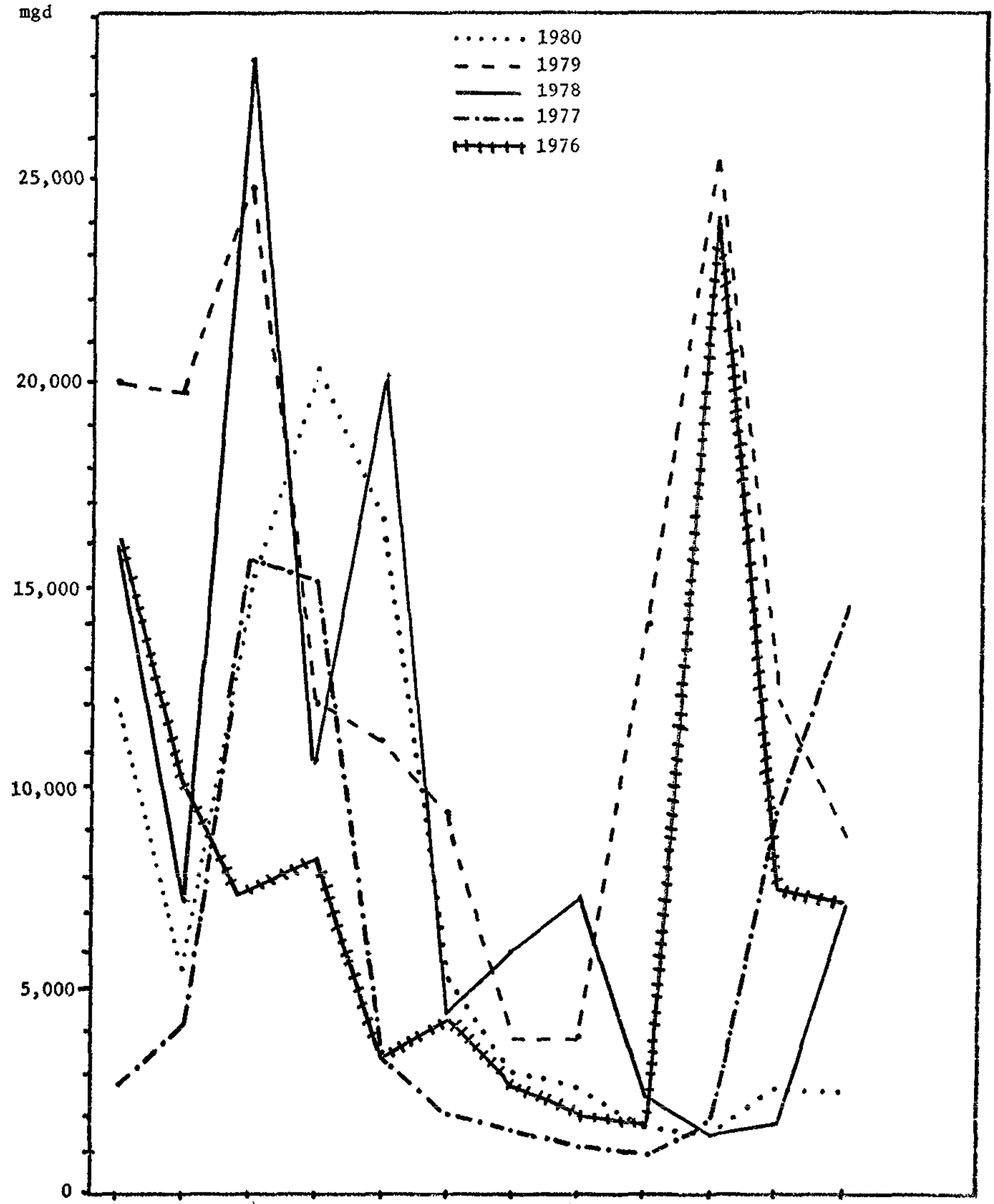


Figure 3-11 Average Total Flow at Little Falls Dam Gage (Including Withdrawals from Study Portion of Potomac) per Month for January 1976 to December 1980 (data from U.S. Geological Survey, 1981, and U.S. Army Corps of Engineers, 1978-1980)

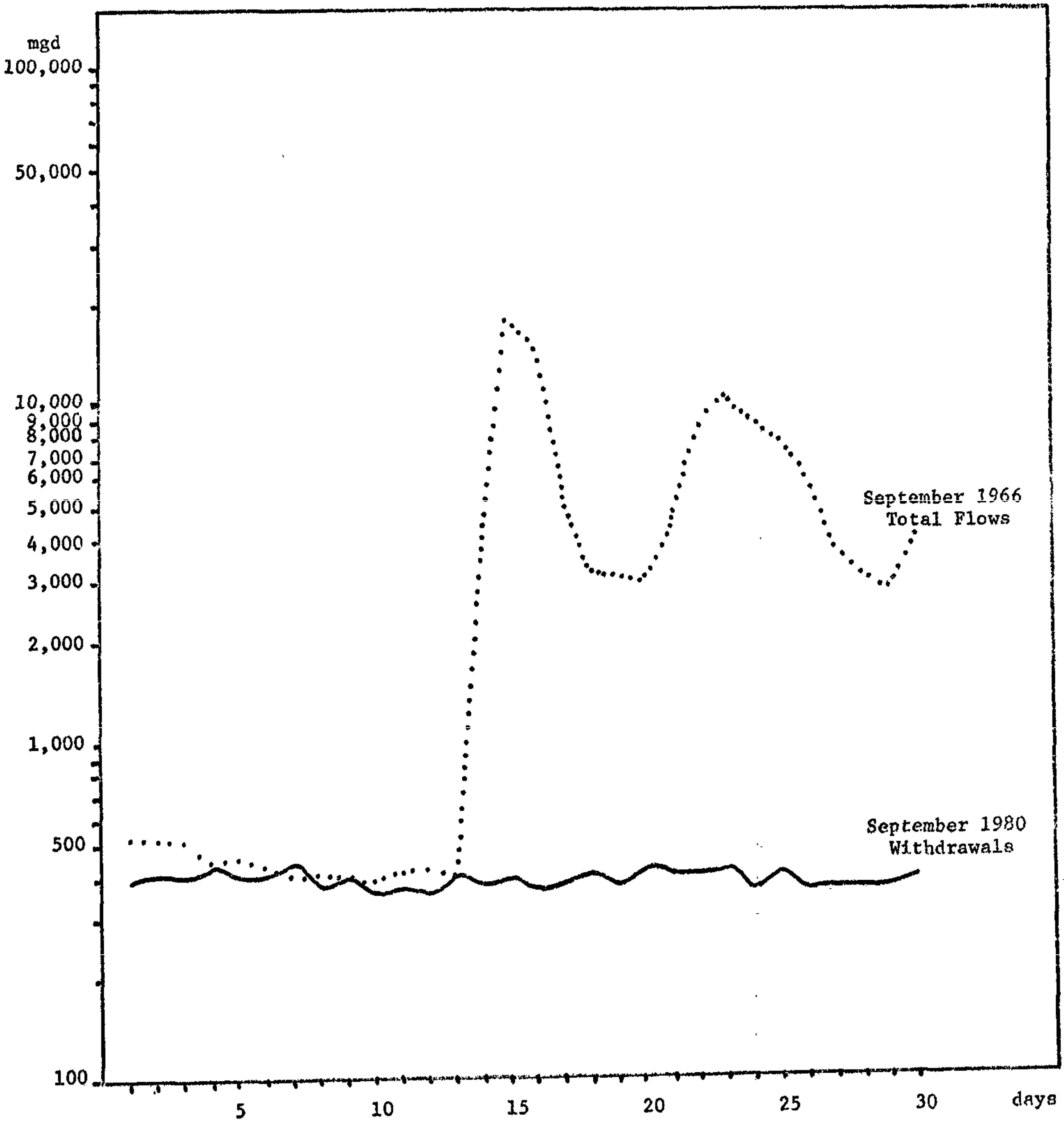


Figure 3-12 Semi-logarithmic Graph of September 1980 Withdrawals and September 1966 Flows (data from the U.S. Army Corps of Engineers and the U.S. Geological Survey, 1981)

pools during their early life stages. The young ducklings of resident nesting waterfowl are totally dependent upon the riverine environment for food and shelter. The adults also depend on the river for food and protection. Resident waterfowl which nest in the study area are mallards, black ducks and wood ducks. Ospreys and occasionally southern bald eagles, both rare and endangered species, use the riverine environment and the upper estuary as a food source and nesting area.

A partially aquatic dependent animal is defined herein as one which either feeds in part on aquatic life or which spends a significant portion of its time in the water. However, these animals are not totally dependent on the river as a food source. The most common partially aquatic mammals are raccoon and mink. Both are partially dependent on river animals and invertebrates as a source of food. There are also several types of birds that are partially dependent such as great blue herons and green herons. Belted kingfishers and several species of waterfowl, such as pied billed grebes, goldeneye and mergansers, commonly visit the study area during the cooler months.

Non-aquatic dependent animals are those which inhabit or frequently visit the lands comprising the near shore flood plain of the river or the river's many islands. These species may occassionally enter the river but are not directly dependent upon it for food, shelter or reproduction. Mammals that are included in this group are grey fox, opossum, skunk, weasel, whitetail deer, squirrels, rats, mice, woodchucks and rabbits. Most song birds which visit the river's shores are considered to belong in this category. Over 108 species of birds have been identified. The peregrine falcon, an endangered species, was observed along the river upstream of the study area in 1978 (Sanderson, 1981). Another sighting has been reported in the vicinity of Violets Lock in the study area.

The Maryland Wildlife Administration's management program includes wild turkey, dove, waterfowl, and squirrel within parts of the study area in Mongtomery County.

2. Fish

The <u>Fishery of the Piedmont Potomac</u>, by Dietemann and Sanderson (1978), includes a compilation of 63 fish species (See Table 3-2) which have been identified by researchers as inhabitants of the Piedmont region of the Potomac. Most of these species may be found in the study portion of the river. Several other fish species have been identified as residents of the study area. These include the hickory shad, quillback carpsucker, white catfish, chain pickerel and several minnow species.

Species / Location (see Figure 1)	Monocacy R. A	Dickerson B	Seneca C	Md. tribs. D	Va. tribs. F	Mather Gorge F	References
PETROMYZONTIDAE							
Sea lamprey *Petromyzon marinus*						0	24
ANGUILLIDAE							
American eel *Anguilla rostrata*	X		X	X	X	X	4,5,15
SALMONIDAE							
Brook trout *Salmo fontinalis*				X	X		5,16
CLUPEIDAE							
Gizzard shad *Dorosoma cepedianum*		X				X	1,21
Alewife *Alosa pseudoharengus*						X	9,14
American shad *Alosa sapidissima*						X	9,14
Blueback herring *Alosa aestivalis*						X	14
AMIIDAE							
Bowfin *Amia calva*	X						21
ACIPENSERIDAE							
Atlantic sturgeon *Acipenser oxyrhynchus*						X	21
CYPRINIDAE							
Blacknose dace *Rhinichthys atratulus*	X			X	X		5,6,13,16
Longnose dace *Rhinichthys cataractae*	X	X	X	X	X	X	1,4,13,16,21
Rosyside dace *Clinostomus funduloides*				X	X		5,6,16
Creek chub *Semotilus atromaculatus*	X	X	X	X	X		1,5,9,13,16
Fallfish *Semotilus corporalis*	X	X	X	X			1,5,9,13
Cutlips minnow *Exoglossum maxillingua*	X	X	X	X	X	X	1,4,5,6,13,16
Golden shiner *Notemigonus crysoleucas*	X	X	X	X	X		1,5,13,16
Silverjaw minnow *Ericymba buccata*	X	X		X			1,5,13
Bluntnose minnow *Pimephales notatus*	X	X	X	X	X	X	1,4,5,9,16,21
River chub *Nocomis micropogon*	X	X	X	X		X	1,4,5,13,21
Stoneroller *Campostoma anomalum*	X	X	X	X			1,4,5,13
Fathead minnow *Pimephales promelas**	X						26
Silvery minnow *Hybognathus nuchalis*	X	X					1,13,
Goldfish *Carassius auratus**	X	X	X			X	1,9,13,21
Carp *Cyprinus carpio**	X	X	X			X	1,4,13,21
Comely shiner *Notropis amoenus*	X	X	X	X			1,4,5,13
Rosyface dace *Notropis rubellus*	X		X	X			4,5,6,13
Swallowtail shiner *Notropis procne*	X	X	X	X	X	X	1,4,5,9,16,21
Satinfin shiner *Notropis analostanus*				X	X	X	5,12,16,21
Common shiner *Notropis cornutus*	X	X	X	X	X		1,4,5,9,13,16
Spottail shiner *Notropis hudsonius*	X	X		X			1,4,5
Spotfin shiner *Notropis spilopterus*	X	X	X	X			1,4,5,9,13
CATOSTOMIDAE							
White sucker *Catostomus commersoni*	X	X	X	X	X	X	1,4,5,6,13,15,21
Hogsucker *Hypentelium nigricans*	X	X		X			1,4,5,6,13
Redhorse sucker *Moxostoma macrolepidotum*	X	X	X			X	1,4,13,21
Creek chubsucker *Erimyzon oblongus*	X	X				X	1,4,21
ICTALURIDAE							
Yellow bullhead *Ictalurus natalis*	X	X		X		X	1,4,13,21,24
Brown bullhead *Ictalurus nebulosis*	X	X			X	X	1,13,16,21
Channel catfish *Ictalurus punctatus**		X	X	X		X	1,5,6,9,21,24
Blue catfish *Ictalurus furcatus**						0	2
Margined madtom *Noturus insignis*	X	X	X	X		X	1,5,12,21
PERCOPSIDAE							
Trout-perch *Percopsis omiscomaycus*			0	0		0	9,12,24
COTTIDAE							
Mottled sculpin *Cottus bairdi*				X			5,6,24
PERCICHTHYIDAE							
White perch *Morone americana*						X	14,21,24
Striped bass *Morone saxatilus*						X	21,24
POECILIIDAE							
Mosquitofish *Gambusia affinis*	X						13
CYPRINODONTIDAE							
Banded killifish *Fundulus diaphanus*	X	X					1,21
CENTRARCIDAE							
Rock bass *Ambloplites rupestris**	X	X	X	X			1,4,5,6,12,13,24
Redbreast sunfish *Lepomis auritus*	X	X		X		X	1,4,6,13,18
Green sunfish *Lepomis cyanellus**	X	X	X	X	X		1,6,9,13,16
Warmouth *Lepomis gulosus**		X				0	1,24
Pumpkinseed sunfish *Lepomis gibbosus*	X	X	X	X		X	1,4,6,9,13
Bluegill sunfish *Lepomis macrochirus**	X	X	X	X	X	X	1,6,9,13,15,16,21
Longear sunfish *Lepomis megalotis**		X			X		1,15,16
Smallmouth bass *Micropterus dolomieui**	X	X	X	X		X	1,4,6,9,13,21,24
Largemouth bass *Micropterus salmoides**	X	X	X	X		X	1,6,9,13,21,24
White crappie *Pomoxis annularis**	X	X	X			X	1,9,21
Black crappie *Pomoxis nigromaculatus**		X			X		1,16
PERCIDAE							
Tessellated darter *Etheostoma olmstedi*	X	X		X	X	X	1,5,13,16,21
Shield darter *Percina peltata*		X	X			X	2,21
Fantail darter *Etheostoma flabellare*	X	X	X	X			1,5,6,12,13
Greenside darter *Etheostoma blennioides*	X	X	X	X		X	1,5,13,21
Walleye *Stizostedion vitreum**						0	1,21
Yellow perch *Perca flavescens*						X	1,21
TOTAL SPECIES = 63	42	42	31	37	19	38	

* introduced

X = present
0 = no recent collections

Table 3-2 Fishes Reported in the Potomac River and Tributaries from Washington, D.C. to the Monocacy River (Dietemann and Sanderson, 1978)

The study area provides a high quality fishery with an abundance of two of the more popular game species, the smallmouth black bass and the largemouth black bass. In recent years studies have determined that reproduction of young bass has been exceptionally high and large catches of adults have been reported (Kreh, 1980). Channel catfish have also become increasingly popular sport fish and the Potomac River has become nationally recognized for its high quality cat fishery (Almy, 1981). Other highly desirable game and pan species which are abundant in the study area of the river are white crappie, black crappie and several varieties of sunfish.

Several anadromous species of fish are also in the study area of the Potomac during portions of each year. These include blueback herring, alewife, American shad, hickory shad, striped bass, white perch, yellow perch and american eel. With the exception of the eel, these species enter the lower fluvial portion of the Potomac below Little Falls Dam each year for spawning purposes. While in the upper estuary and lower fluvial portion of the river, the adults of some species provide a viable sport fishery. The young inhabit the lower fluvial river during their early life cycle and eventually migrate downstream to the Potomac estuary and beyond.

During the 1930's, walleyes were reported to be commonly caught by fishermen in the lower fluvial river and the upper estuary. However, more recently, reports of catches of this species have become exceedingly rare and recent fish sampling studies have not been able to confirm the continued presence of this species in the river. At this time the Maryland Wildlife Administration is attempting to restore this fishery.

The fluvial Potomac River is capable of supporting approximately 180 lbs of harvestable size fish per acre (Sanderson, 1958). Game fish and panfish, preferred by anglers, form about 52 percent of the total fish population. So called "rough fish" or less desirable fish species, constitute 48 percent of the population. By weight, however, the popular game fish and panfish constitute only 40 percent of total fish biomass (See Appendix A for data derived from fishery sampling efforts in: 1975, 1976, 1978 and 1980 conducted in coordination with the Potomac Low Flow Study).

3. Aquatic Vegetation

Lowell Keup and Delbert Hicks (1978) sampled rooted aquatic plants from Great Falls upstream to the confluence of the Savage River, a distance of about 220 miles. Investigations also were made of the Monocacy, Antietam, Conococheague, South Branch Potomac, Cacapon and Shenandoah tributaries.

Rooted aquatic plants store nutrients during the spring and summer growing season. In autumn these plants decay and the stored nutrients are released and pass downstream. These nutrients provide only a small part of the total chemical load carried annually by the river. These rooted aquatics seasonally provide for some measure of erosion control as well as cover for fish and wildlife. Some species of plants serve as foods for fish and wildlife, especially waterfowl and muskrats.

During low-flow study data collection conducted in 1978 and 1980, rooted aquatic plants were noticeably sparse within the study reach, with the exception of a profuse stand of water willow, Justicia americana, which covered Seneca Dam. Seneca Dam, a low rubble dam that feeds water to the Chesapeake and Ohio Canal is constructed of rock, gravel and coarse sand. The dam's construction makes it an ideal substrate for this species of rooted aquatic plant. Associated with the rooted aquatic vegetation and this substrate is an abundance of aquatic insects which serve as food organisms for smallmouth bass, channel catfish, and red breasted sunfish. Water willow was the only rooted aquatic plant species observed in the study portion of the river.

4. Microbiota

Microbiota are those living organisms which are too small to be seen individually without magnification. In the natural aquatic environment these consist primarily of phytoplankton, small zooplankton, benthic microbes and bacteria. Other land and air dwelling microbes enter the aquatic environment via eroding sediment, sewerage plant effluent, airborne dust, etc., and survive for a period of time. These organisms provide food for the larger zooplankton and benthic macroinvertebrates, both of which are ultimately eaten by fish.

Phytoplankton appear to be the base of the aquatic food chain in the fluvial Potomac River because turbidity and scouring action of flow tend to severely depress the populations of benthic photosynthetic organisms (i.e. benthic algae, mosses, etc.), zooplankton and the larger rooted vegetation. The major phytoplankton that inhabit the river are coccoid blue green algae, filamentous blue green algae, coccoid green algae, filamentous green algae, green flagellates, other coccoid algae, other pigmented flagellates, centric diatoms, and pennate diatoms (See Tables 3-3, 3-4 and 3-5). Within these groups, the species composition and abundance of phytoplankton generally reflect the concentration of organic and inorganic nutrients in the river water. However, water temperature, light, turbidity and other chemical water quality factors effect species composition and abundance (Weber, Mason and Rasin, 1978). Weber, Mason, and Rasin (1978) studied the phytoplankton at Great Falls and other

Genus	58	59	60	61	62	63	64	65	66	67
Coccoid Blue Green Algae										
Anacystis	X	X	X	X	X	X				
Gomphosphaeria		X								
Filamentous Blue Green Algae										
Anabaena	X									
Lyngbya					X					
Oscillatoria	X	X			X	X				
Phormidium		X			X	X				
Raphidiopsis				X	X	X				
Coccoid Green Algae										
Actinastrum				X		X	X		X	X
Ankistrodesmus	X	X	X	X		X	X	X	X	X
Characium		X								
Chlorella (type)	X	X			X	X				
Chlorococcum	X									
Coelastrum				X	X			X		
Cosmarium	X				X		X			
Crucigenia					X				X	
Dictyosphaerum				X		X		X	X	
Golenkinia				X	X			X		
Kirchneriella					X	X	X		X	X
Lagerheimia					X	X	X		X	X
Micractinium				X			X		X	X
Oocystis			X	X	X			X	X	X
Palmellococcus		X	X							
Pediastrum	X						X			
Scenedesmus	X	X	X	X	X	X	X	X	X	X
Schroederia		X			X					
Selenastrum	X									
Staurastrum		X								
Tetradesmus		X		X	X	X				
Treubaria					X					
Filamentous Green Algae										
Mougeotia						X	X			
Green Flagellates										
Chlamydomonas	X	X		X	X	X	X	X	X	X
Euglena	X	X		X	X	X	X	X	X	
Phacus				X			X			
Trachelomonas				X			X		X	
Other Coccoid Algae										
Chrysocapsa					X					
Other Pigmented Flagellates										
Chromulina	X		X		X					
Chrysococcus						X	X	X		X
Dinobryon				X						
Gymnodinium		X								
Peridinium	X					X				
Centric Diatoms										
Cyclotella	X	X	X	X	X	X	X	X	X	X
Melosira	X	X	X	X	X	X	X		X	X
Stephanodiscus	X	X	X	X	X	X	X	X	X	X
Pennate Diatoms										
Achnanthes	X		X	X	X	X	X	X	X	X
Amphipleura						X	X		X	
Amphora		X	X	X	X	X			X	
Anomoeoneis									X	
Asterionella	X			X		X	X		X	X
Bacillaria						X	X			
Caloneis				X	X					
Ceratoneis	X		X				X			
Cocconeis	X	X	X	X	X	X	X	X	X	
Cymatopleura		X	X	X						
Cymbella	X	X	X	X	X	X	X	X	X	X
Denticula			X	X	X					
Diatoma	X	X	X	X	X	X	X	X	X	X
Diploneis			X	X	X	X				
Epithemia			X	X	X	X		X	X	
Eunotia		X	X	X	X	X	X	X	X	
Fragilaria	X	X	X	X	X	X	X	X	X	X
Frustulia		X	X	X	X					
Gomphonema	X	X	X	X	X	X	X	X	X	X
Gyrosigma		X	X	X	X	X	X			
Meridion	X		X	X	X	X	X	X	X	
Navicula	X	X	X	X	X	X	X	X	X	X
Neidium			X	X	X					X
Nitzchia	X	X	X	X	X	X	X	X	X	X
Pinnularia	X	X	X	X	X	X	X		X	
Pleurosigma	X	X			X					
Rhoicosphenia	X	X		X	X		X		X	X
Rhopalodia									X	
Surirella		X	X	X	X	X	X	X	X	
Synedra	X	X	X	X	X	X	X	X	X	X
Tabellaria	X		X	X	X				X	

Table 3-3 Plankton Genera in the Potomac River at Williamsport (Weber, Mason and Rasin, 1978)

Genus	58	59	60	61	62	63	64	65	66	67
Coccoid Blue-green Algae										
Agmenellum	x	x	x		x	x			x	
Anacystis	x	x	x	x	x	x	x			
Gomphosphaeria		x	x		x		x			
Filamentous Blue-green Algae										
Anabaena	x					x				
Aphanizomenon						x				
Calothrix		x								
Gleothrichia	x									
Oscillatoria	x	x								
Phormidium	x	x								
Rhaphidiopsis				x	x	x				
Coccoid Green Algae										
Actinastrum	x	x	y	x	x	x	x	x	x	x
Ankistrodesmus	x	x	x	x	x	x	x	x	x	x
Characium		x								
Chlorella (type)	x	x		x	x	x				
Chlorococcum	x			x						
Closteriopsis	x									
Closterium		x	x	x		x				
Coelastrum	x	x	x	x	x	x	x		x	
Cosmarium				x						x
Crucigenia	x	x	x	x	x	x	x		x	
Dictyosphaerium	x	x	x	x	x	x	x	x	x	
Dimorphococcus						x				
Elakatothrix						x				
Gloeocystis	x		x						x	
Golenkinia		x			x	x	x	x	x	
Kirchneriella		x	x	x	x	x	x	x	x	x
Lagerheimia		x		x	x	x	x	x	x	x
Micractinium		x	x		x	x	x	x	x	x
Nannochloris					x					
Nephrocytium							x			
Oocystis		x	x	x	x	x	x		x	x
Ophiocytium					x					
Palmellococcus			x		x					
Pediastrum	x	x		x		x	x		x	x
Planktosphaeria					x					
Polyedriopsis						x				
Scenedesmus	x	x	x	x	x	x	x	x	x	x
Schroederia		x		x	x	x				
Selenastrum				x						
Sphaerocystis	x	x			x					
Staurastrum		x								
Tetradesmus		x		x	x	x				
Tetraedon	x		x		x	x			x	x
Tetrastrum		x		x			x		x	
Treubaria				x	x	x	x			
Westella					x					
Filamentous Green Algae										
Spirogyra					x					
Green Flagellates										
Chlamydomonas	x	x	x		x	x	x	x	x	x
Chlorogonium		x			x					
Eudorina							x			
Euglena		x		x	x	x	x		x	
Xephyrion									x	
Pandorina				x		x	x			
Phacotus		x	x	x	x	x	x		x	
Trachelomonas		x	x	x	x	x	x		x	
Other Pigmented Flagellates										
Chromulina			x	x	x	x				
Chrysococcus						x	x		x	
Gymnodinium		x			x					
Mallomonas	x									
Peridinium		x								
Centric Diatoms										
Cyclotella	x	x	x	x	x	x	x	x	x	x
Melosira	x	x	x	x	x	x	x		x	
Stephanodiscus		x	x	x	x	x	x	x	x	x
Pennate Diatoms										
Achnanthes		x	x	x	x	x	x	x	x	x
Amphipleura		x								
Amphora	x	x	x	x		x	x		x	x
Asterionella	x				x			x		x
Bacillaria					x					
Caloneis				x			x	x		
Ceratoneis					x				x	
Cocconeis		x	x	x	x	x	x	x		
Cymatopleura		x	x							
Cymbella	x	x	x	x	x	x	x	x	x	x
Denticula			x							
Diatoma	x	x	x	x	x	x	x		x	x
Diploneis			x	x					x	x
Epithemia		x		x						
Eunotia			x	x	x	x		x	x	
Fragilaria	x	x	x	x	x		x		x	x
Frustulia			x	x	x			x		
Gomphoneis		x			x	x				
Gomphonema	x	x	x	x	x	x	x	x	x	x
Gyrosigma		x	x	x	x	x	x			
Hantzschia				x						
Meridion	x		x	x	x			x	x	x
Navicula	x	x	x	x	x	x	x	x	x	x
Neidium		x		x						
Nitzschia	x	x	x	x	x	x	x	x	x	x
Opephora		x								
Pinnularia	x	x	x	x	x	x	x		x	x
Pleurosigma		x			x					
Rhoicosphenia	x	x	x	x	x	x	x	x	x	x
Rhopalodia				x			x			
Stauroneis		x								
Surirella	x	x	x	x	x			x	x	x
Synedra	x	x	x	x	x	x	x	x	x	x
Tabellaria	x	x	x		x					

Table 3-4 Plankton Genera in the Potomac River at Great Falls (Weber, Mason and Rasin, 1978)

Genus	Year 63	64	65	66	67
Coccoid Blue-green Algae					
Agmenellum	X	X	X		
Anacystis		X			
Gomphosphaeria		X			
Filamentous Blue-green Algae					
Oscillatoria	X			X	
Coccoid Green Algae					
Actinastrum	X	X	X	X	X
Ankistrodesmus	X	X	X	X	X
Coelastrum	X		X	X	
Cosmarium			X		X
Crucigenia	X	X	X	X	X
Dictyosphaerium	X	X	X	X	X
Elakatothrix	X		X		
Franceia			X	X	
Golenkinia	X	X	X	X	
Kirchneriella	X	X	X	X	X
Lagerheimia		X	X	X	X
Micractinium	X	X	X	X	X
Nephrocytium		X			
Oocystis	X	X	X	X	X
Pediastrum	X	X	X	X	X
Polyedriopsis				X	
Scenedesmus	X	X	X	X	X
Schroederia					X
Sphaeroscystis			X		
Staurastrum		X		X	
Tetrastrum		X	X	X	
Tetraedron	X	X	X	X	X
Treubaria	X	X		X	
Filamentous Green Algae					
Binuclearia				X	
Mougeotia				X	
Green Flagellates					
Chlamydomonas	X	X	X	X	X
Eudorina		X	X		
Euglena	X	X	X	X	
Pandorina	X	X		X	
Phacus				X	
Pteromonas		X	X	X	
Trachelomonas	X	X		X	
Other Pigmented Flagellates					
Chrysococcus		X	X		
Dinobryon			X		
Kephyrion				X	
Lagynion			X		
Mallomonas	X		X		
Peridinium	X		X		
Centric Diatoms					
Cyclotella	X	X	X	X	X
Melosira	X	X	X	X	X
Stephanodiscus	X	X	X	X	X
Pennate Diatoms					
Achnanthes	X	X	X	X	X
Amphora	X	X	X	X	
Asterionella	X	X	X		
Caloneis				X	
Cocconeis	X	X	X	X	X
Cymbella	X	X	X	X	X
Diatoma	X	X	X	X	X
Epithemia		X			
Eunotia				X	
Fragilaria	X	X	X	X	X
Frustulia		X		X	
Gomphonema		X	X	X	X
Gyrosigma		X		X	
Meridion		X		X	
Navicula	X	X	X	X	X
Nitzschia	X	X	X	X	X
Opephora	X				
Pinnularia	X	X			
Rhoicosphenia				X	X
Stauroneis				X	
Surirella	X	X	X	X	X
Synedra	X	X	X	X	X

Table 3-5 Plankton Genera in the Potomac River at Washington, D.C. (Weber, Mason and Rasin, 1978)

sites on the Potomac. They have concluded that the total counts and taxonomic compositions of the phytoplankton in the river are characteristic of water which contain high concentrations of organic and inorganic nutrients. Changes in the dominant organisms during the period of operation of the National Water Quality Network from 1958-1967 are indicative of increasing concentrations of nutrients. These changes were also observed by Bartsch (1954), and Jaworski (1972).

Bacteria play an important role in waste decomposition within the river ecosystem. They are capable of tolerating a wide range of physical and chemical variability within the aquatic environment.

5. Benthic Macroinvertebrates

Benthic Macroinvertebrates are herein defined as a miscellaneous group of macroscopic animals which do not have backbones and which inhabit the river bottom or substrate during a substantial portion of their life cycles. These animals feed primarily on living microinvertebrates, plants and detritus and in turn are an extremely important element in the food chains of larger fish and wildlife.

Quantitative sampling of benthic macroinvertebrates at nine individual one-square-foot sites across each of three riffle areas sampled on the Potomac River at Seneca, Carderock and Little Falls, showed these areas to be highly productive and diverse habitats for these organisms. Aquatic insects are the dominant benthic macroinvertebrates representing 81 of the 95 different types of organisms collected and 93 percent of the total number of organisms. The non-insect benthic macroinvertebrates are for the most part molluscs including clams and snails and representing 7 taxa and 6.2 percent of total numbers. The remaining non-insect forms included flatworms, leeches, amphipods, isopods and aquatic earthworms comprising 8 taxa and 0.8 percent of total numbers.

Caddisflies are the dominant riffle inhabitants constituting about 60 percent of total organisms. Dipterans ranked second, mayflies third and aquatic beetles fourth. The molluscs ranked fifth with clams and snails about equally represented. Ubiquitous organisms found at all 27 riffle transect sites were the caddisflies, Hydropsyche phalerata and macronema sp. and the larval aquatic moth, Parargyractis fulicalis.

In terms of total numbers, number of genera, and diversity indices at individual one square foot sampling sites, a few sites showed slight stress while the majority appeared normal. This indicates good to excellent stream quality. Combining sites into three square-foot composites suggested an excellent stream quality with some enrichment indicated. The number of taxa at all sample locations remained relatively constant with most of the differences involving rarer forms.

There was some variability in total numbers of organisms across and down the river. At the Seneca transect minimal numbers occurred on the Maryland side whereas the reverse was true at the Little Falls transect, with maximum and relatively uniform numbers occurring across the Carderock transect. The Virginia side showed a downriver decline in total numbers while at mid-river and on the Maryland side numbers increased from Seneca to Carderock and then decreased at the Little Falls transect. Most of these differences can be accounted for by reductions in the dominant caddisflies and dipterans, and it is difficult to determine the significance of these reductions (30 to 40 percent) due to the possible effects of emergence, competition and predation along with the vagaries of sampling small portions of an extremely large habitat.

Two exotic molluscs, the Asiatic clam, Corbicula fluminea and the faucet snail, Bithynia tentaculata appear to be well established in the study portion of the Potomac.

Qualitative sampling in shallow and deep pool areas, and in water willow stands, generally showed a much less diverse and abundant benthic macroinvertebrate fauna with forms more tolerant of siltation and enrichment. The water willow (Justicia americana) habitat appeared to be the more diverse of these qualitative sample sites.

There was no quantitative benthic macroinvertebrate data collected in similar large riffle areas of the Potomac with which to compare present findings. Prior routine monitoring work was done with artificial substrate samplers placed closer to shore in the quieter, slow-moving waters, reflective of the less diverse conditions of the pool areas. Similar macroinvertebrate communities in terms of number and diversity have previously been found in riffle areas sampled near the mouth of Conococheague Creek and the Monocacy River.

A complete test of "Potomac River Low Flow Study Benthic Macroinvertebrate Findings" is presented in Appendix B (See Figure 3-13 for maps of the Benthic Macroinvertebrate sampling sites).

D. Chemical

"Despite its reputation, the fluvial Potomac and its freshwater streams are among the cleanest of those in America's major river basins. Some pollution from small municipalities -- all are relatively small except those in the Metropolitan Washington Area -- remains to be corrected. Most of the relatively few major industries are in compliance with or on schedule to meet, effluent and water quality requirements" (Interstate Commission on the Potomac River Basin, 1978).

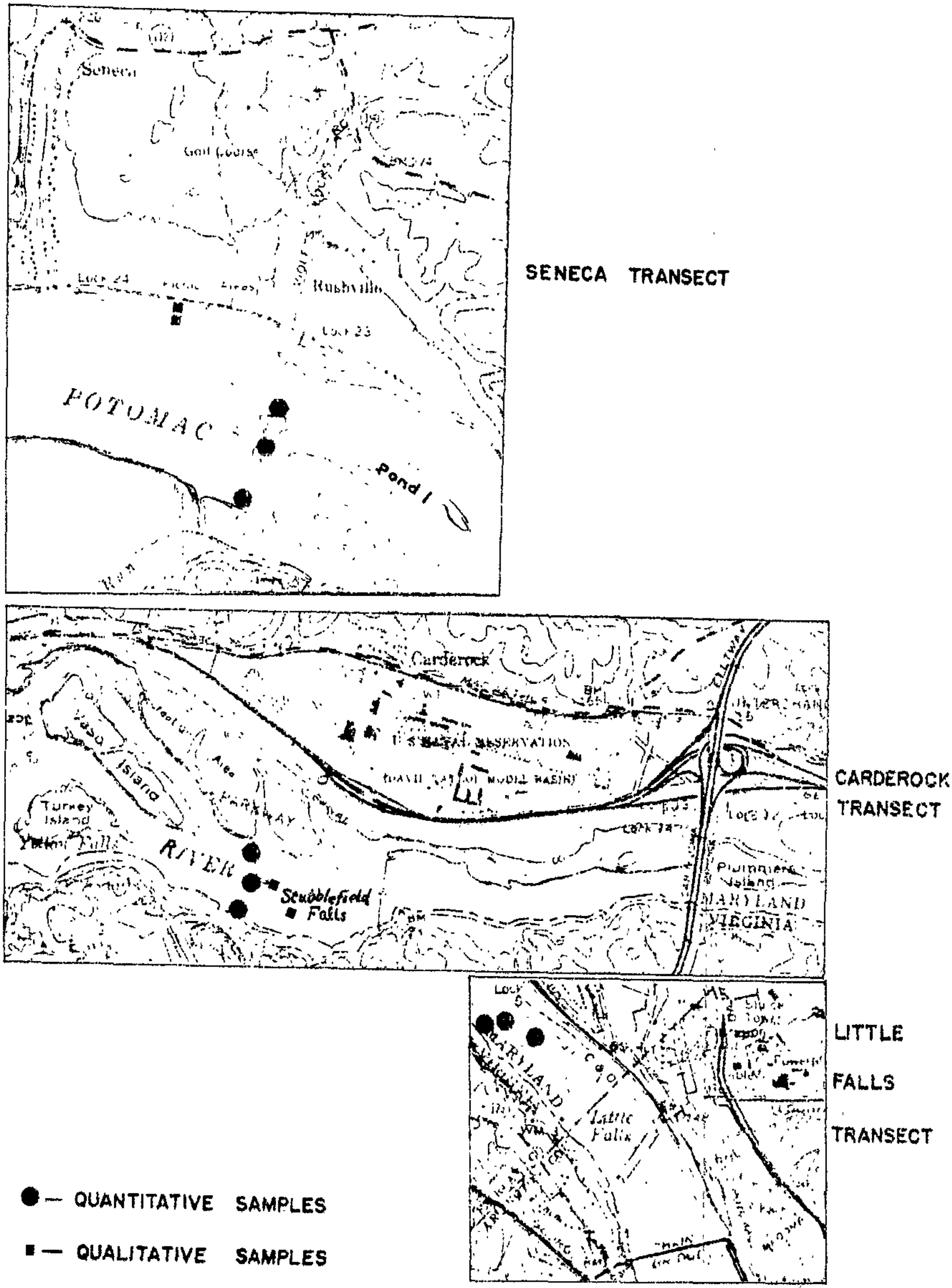


Figure 3-13 Benthic Macroinvertebrate Sample Sites

Documented at the symposium was the status of fish and other inhabitants of the aquatic communities of the fluvial river which have responded to the improved and generally adequate water quality for aquatic life that occurs as a result of environmental quality control efforts within the river basin.

The Interstate Commission on the Potomac River Basin summarized the Potomac River basin water quality status and prepared a trend assessment for the years 1962-1973 (ICPRB, 1975). The ICPRB concluded that during the period 1962-1973 the mainstream from 10 miles below Cumberland to Great Falls (150 river miles) was generally of good quality and supported recreation and aquatic life. In the 20 mile free flowing reach of the river from Great Falls to the estuary it was reported that increasing nutrient levels, oxygen demanding wastes, and silt and bacteria were present. A "Water Quality Status and Trend By Station" analysis for the lower fluvial portion of the river and some of its major tributaries, which appeared in Potomac River Basin Water Quality 1978-79 (Interstate Commission on the Potomac River Basin, 1980) is presented in Table 3-6.

Erosion at construction sites within the river basin also adds to the heavy sediment load carried annually by the Potomac River. The U.S. Geological Survey reported that in 1979 approximately 2.03 million tons of sediment was carried by the river past Point of Rocks upstream of the study area. Heavy sediment loading by itself may limit the biologic productivity of desirable aquatic life, adversely effect recreational use of the river and add to the cost of water purification at the downstream public water supply intakes.

The following brief summary description of the important water quality parameters of the reach of the Potomac between Harpers Ferry and Chain Bridge (Washington D.C.) is quoted from the Metropolitan Washington Water Quality Management Plan published by the Metropolitan Washington Council of Governments (1978) (COG). Figures 3-14 through 3-23, are also adapted from the COG plan. The figures graphically demonstrate the effects of low vs. high flows on chemical constituents at various sampling stations within the study area.

Dissolved Oxygen

Samplings indicated excellent conditions during both the 1972 high flow and the 1976 low flow years. Values for average daily dissolved oxygen rarely dropped below 7 mg/l, and uniformly met state standards of 4.0 mg/l minimum and 5.0 mg/l.

BOD_5

Summer BOD_5 values averaged approximately 3 mg/l and winter values averaged approximately 1.5 mg/l. Both of these values were well under the 5 mg/l level generally viewed as indicating polluted waters.

Table 3-6

Water Quality Status and Trend by Station (1978-1979)*

Seneca Creek at River Road

Status: Fair-Good Water Quality
Limiter: Bacteria, NO_3, pH
Source: Runoff
Trend: Not discernible

Cabin John Creek at Macarthur Blvd.

Status: Fair-Good Water Quality
Limiter: Bacteria, NO_3
Source: Runoff
Trend: Improving

Potomac River at Little Falls Dam, MD

Status: Fair Water Quality (Poor at low flows)
Limiter: Bacteria, NO_3
Source: Municipal Wastewater, Urban and Ag. runoff, water treatment plant wastes
Trend: Not discernible

Potomac River at Fletcher's Boat House

Status: Fair-Good Water Quality
Limiter: Bacteria
Source: Delapidated Sanitary Sewer, Runoff

Rock Creek at Virginia Avenue

Status: Fair-Poor Water Quality
Limiter: Bacteria, Sediment
Source: Runoff, Combined Sewer Systems
Trend: Not descernible

*Potomac River Basin Water Quality 1978-79 (Interstate Commission on the Potomac River Basin, 1980)

Figure 3-14

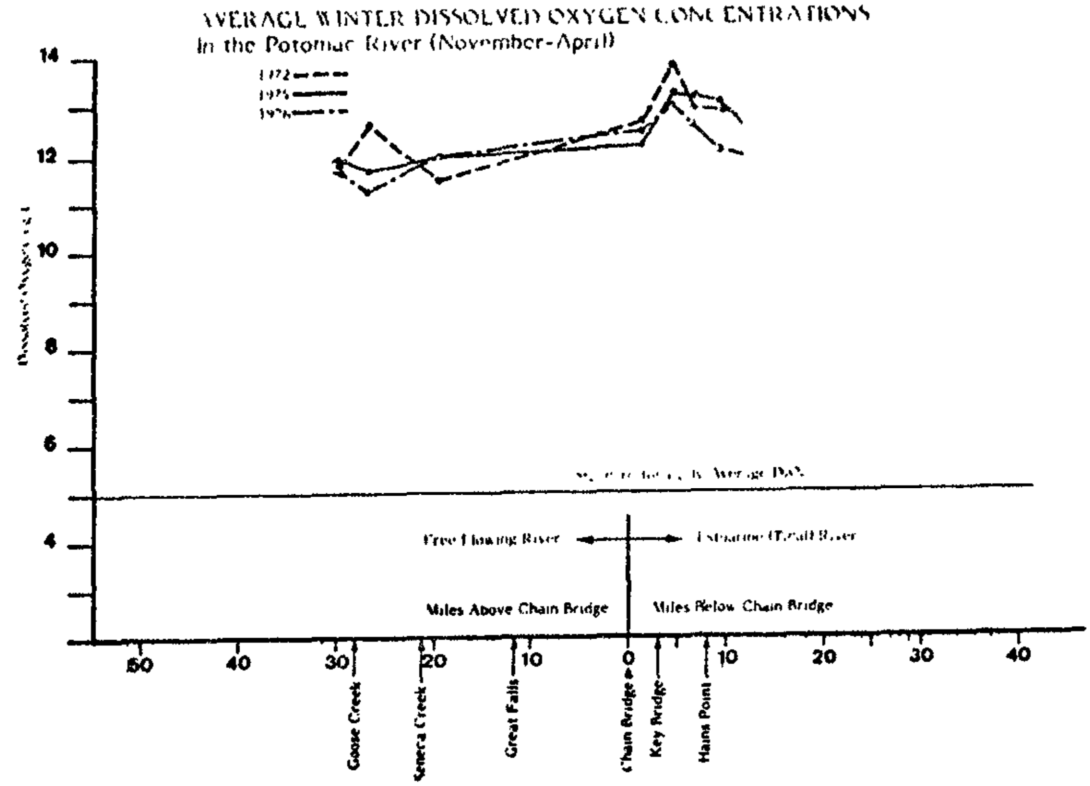


Figure 3-15

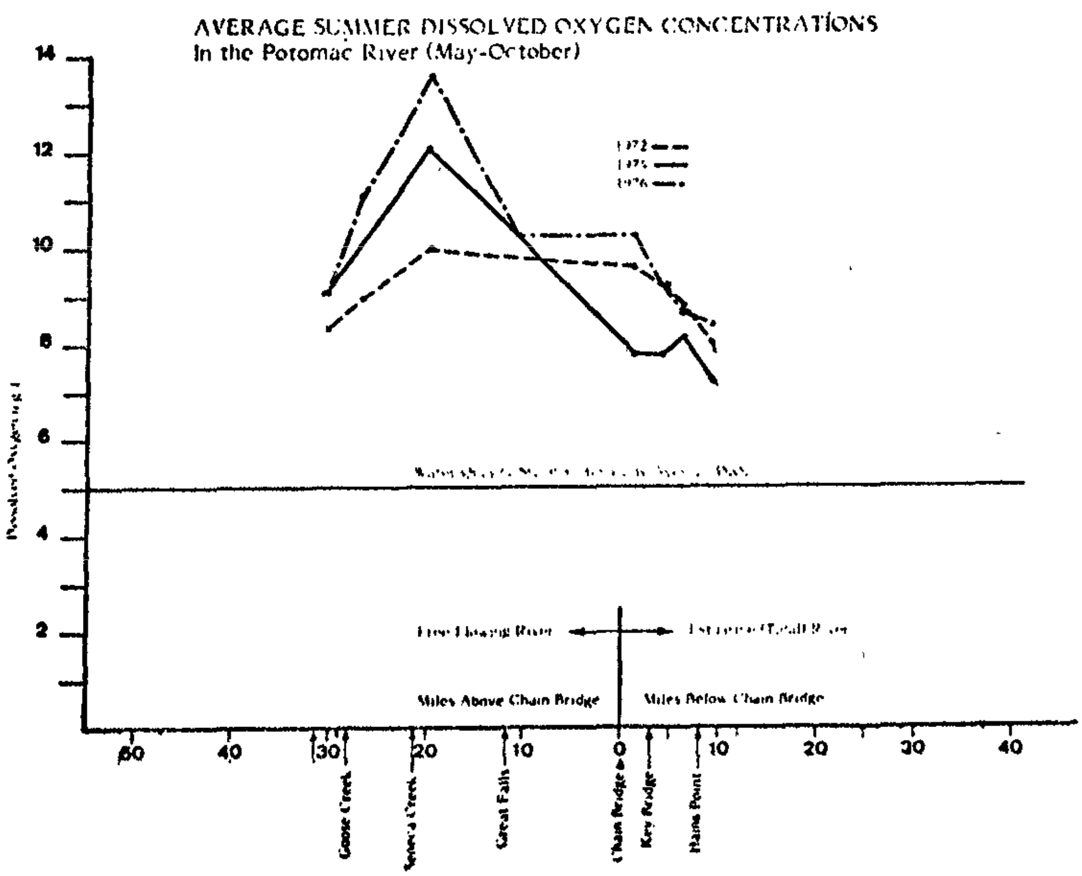


Figure 3-16

1977 LOW FLOW DISSOLVED OXYGEN CONCENTRATIONS
In the Potomac River (June - November)

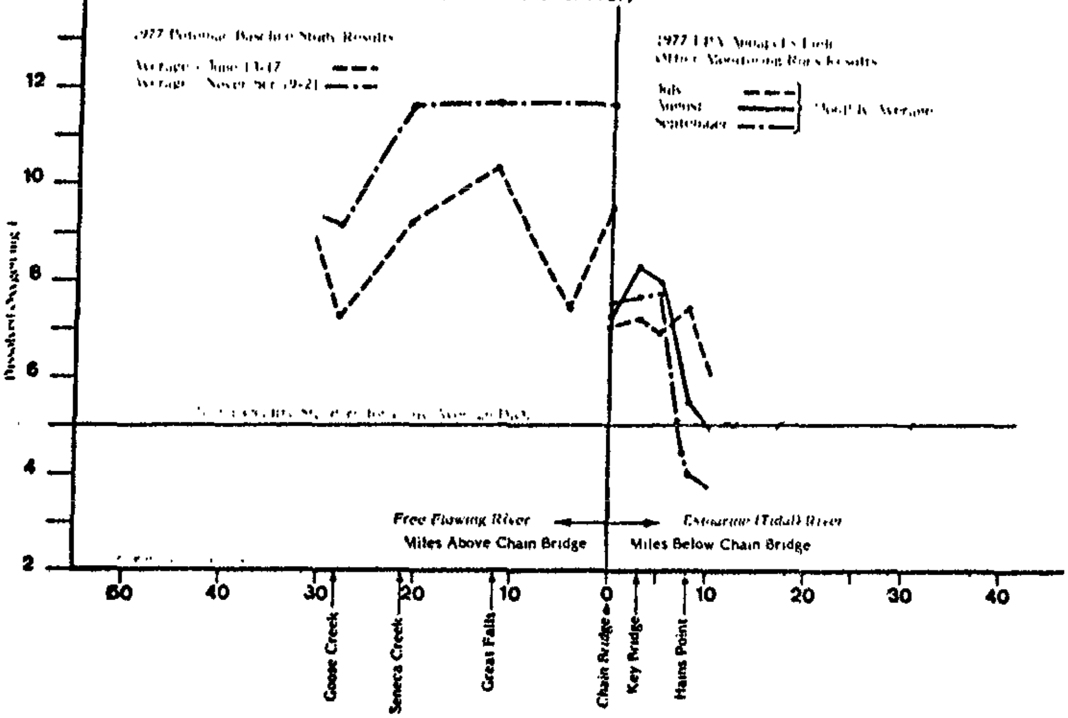


Figure 3-17

1972 HIGH FLOW SUMMER DISSOLVED OXYGEN (May - October)

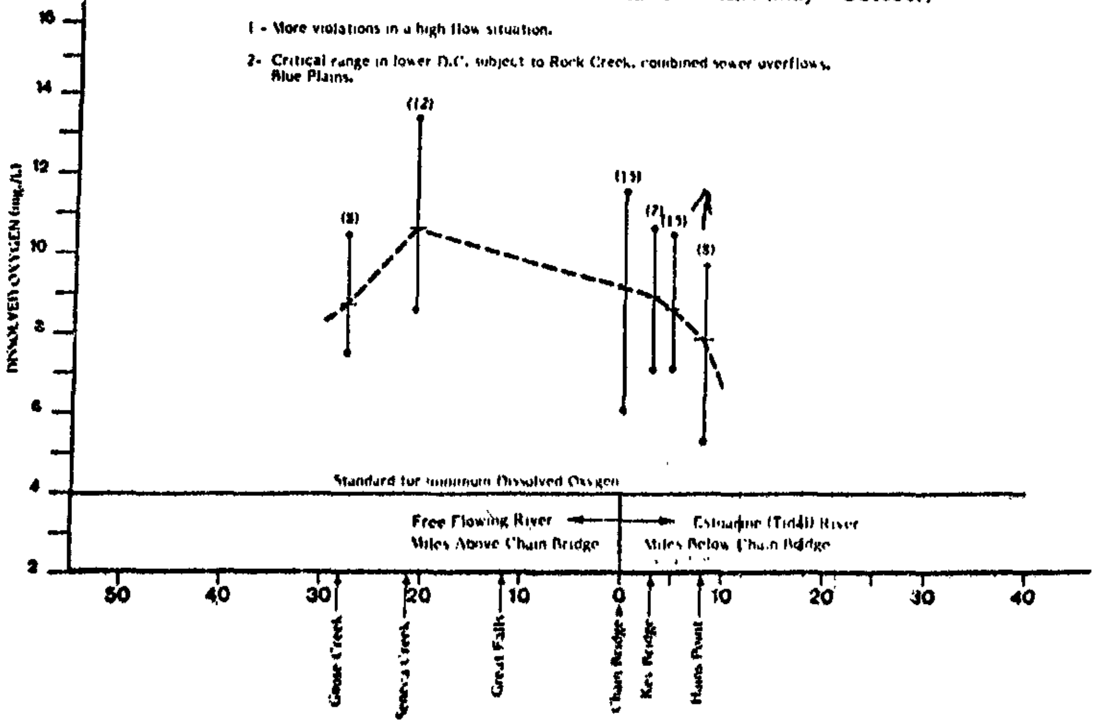


Figure 3-18

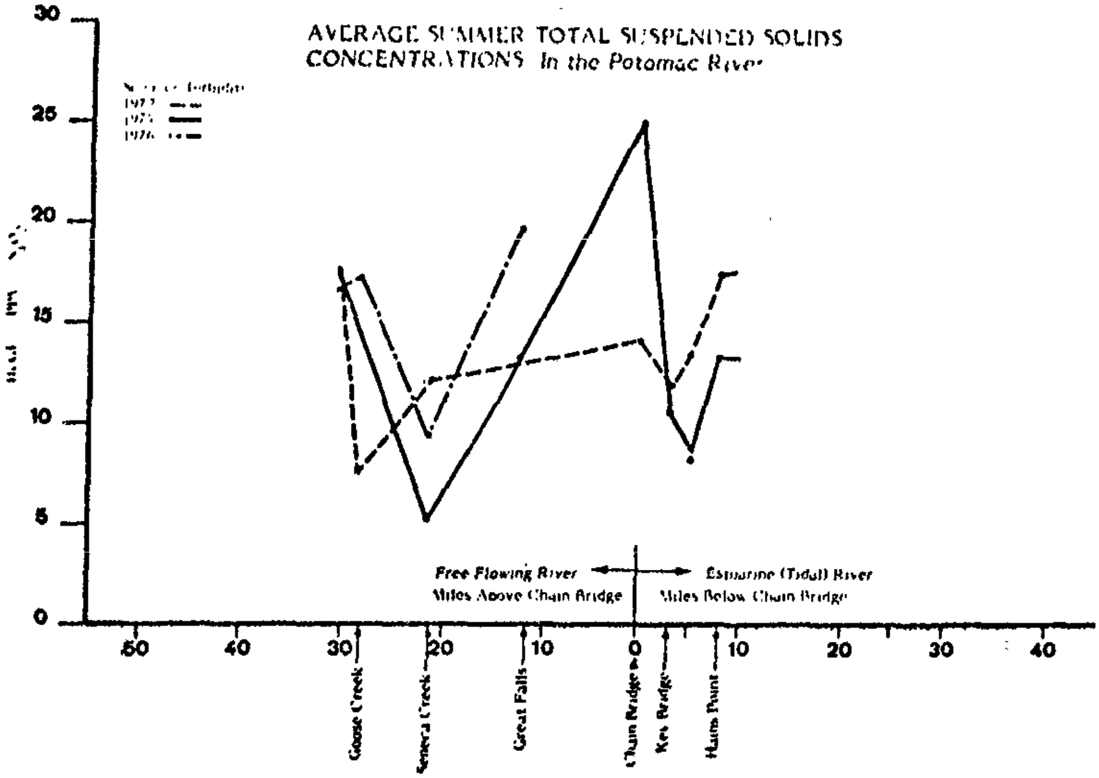


Figure 3-19

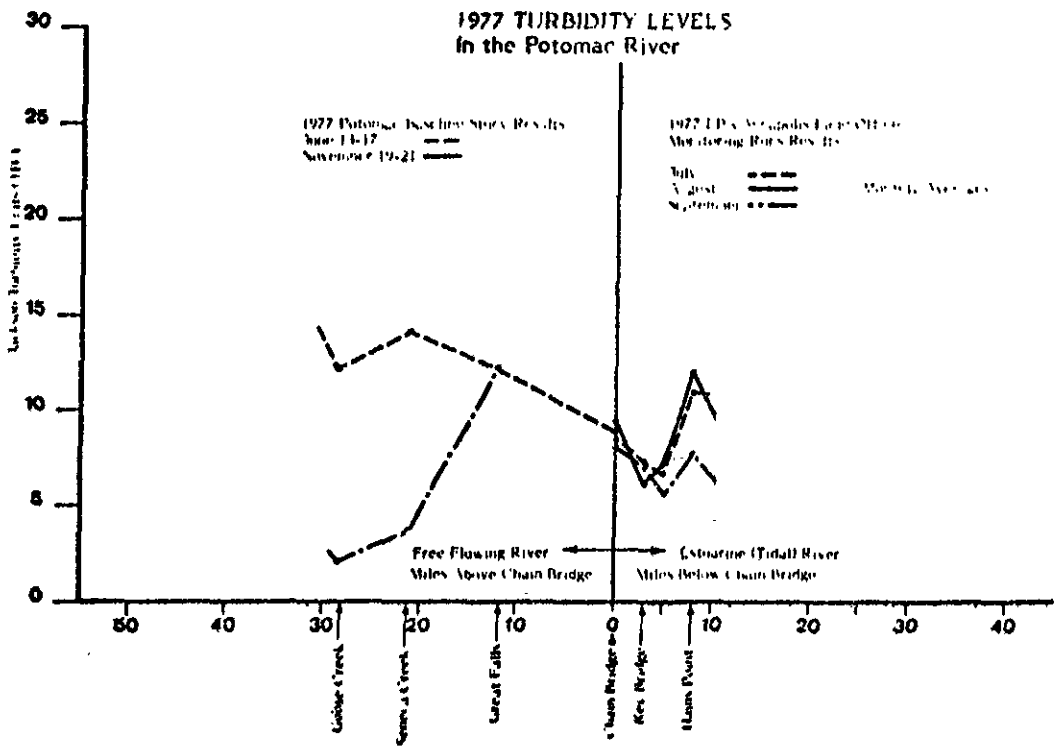


Figure 3-20

AVERAGE SUMMER TEMPERATURES
In the Potomac River (June-November)

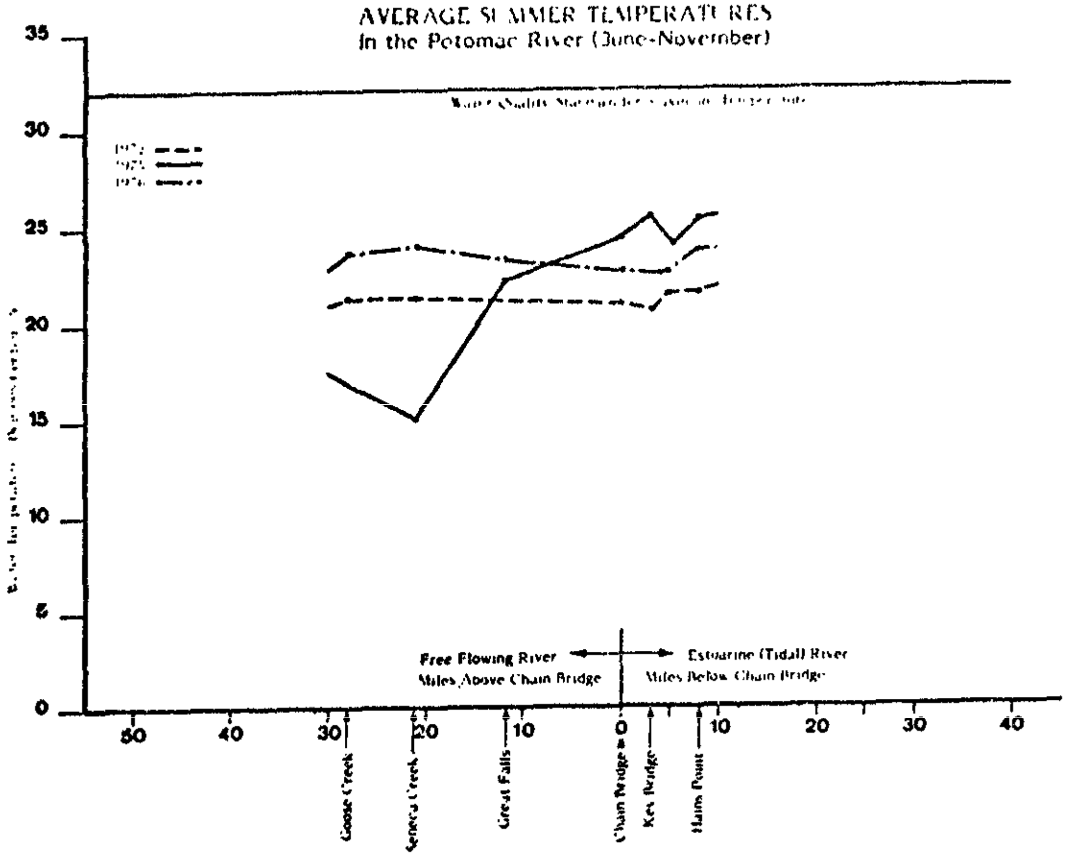


Figure 3-21

SUMMER BOD_5
In the Potomac River (June-November)

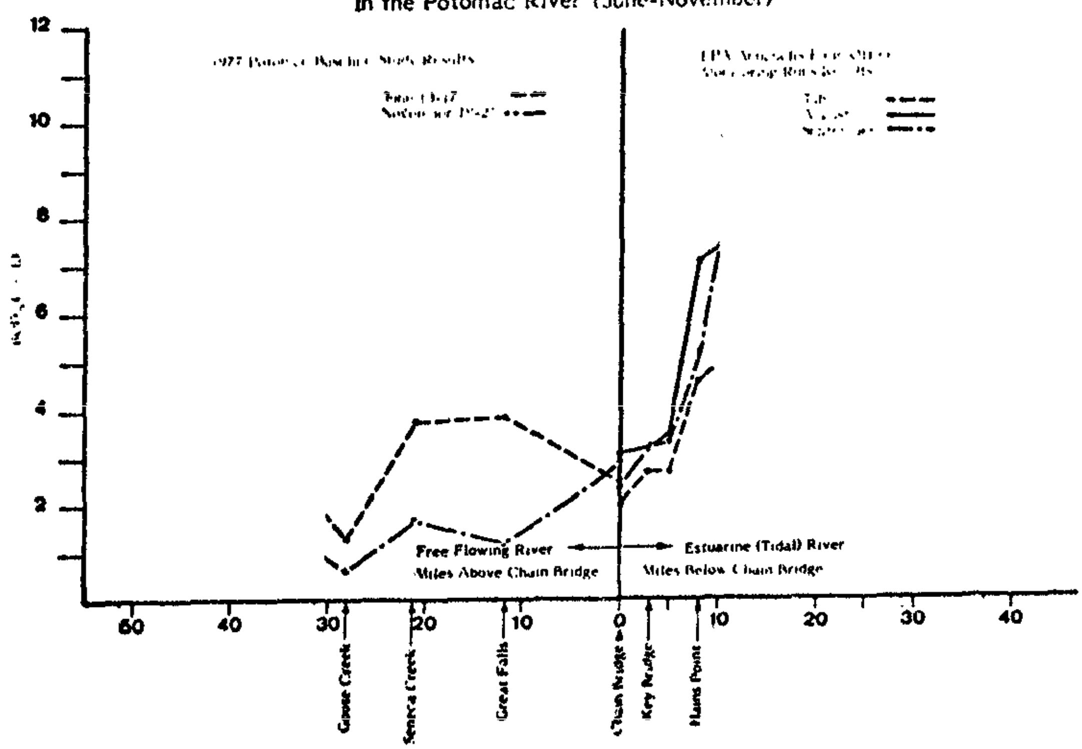


Figure 3-22

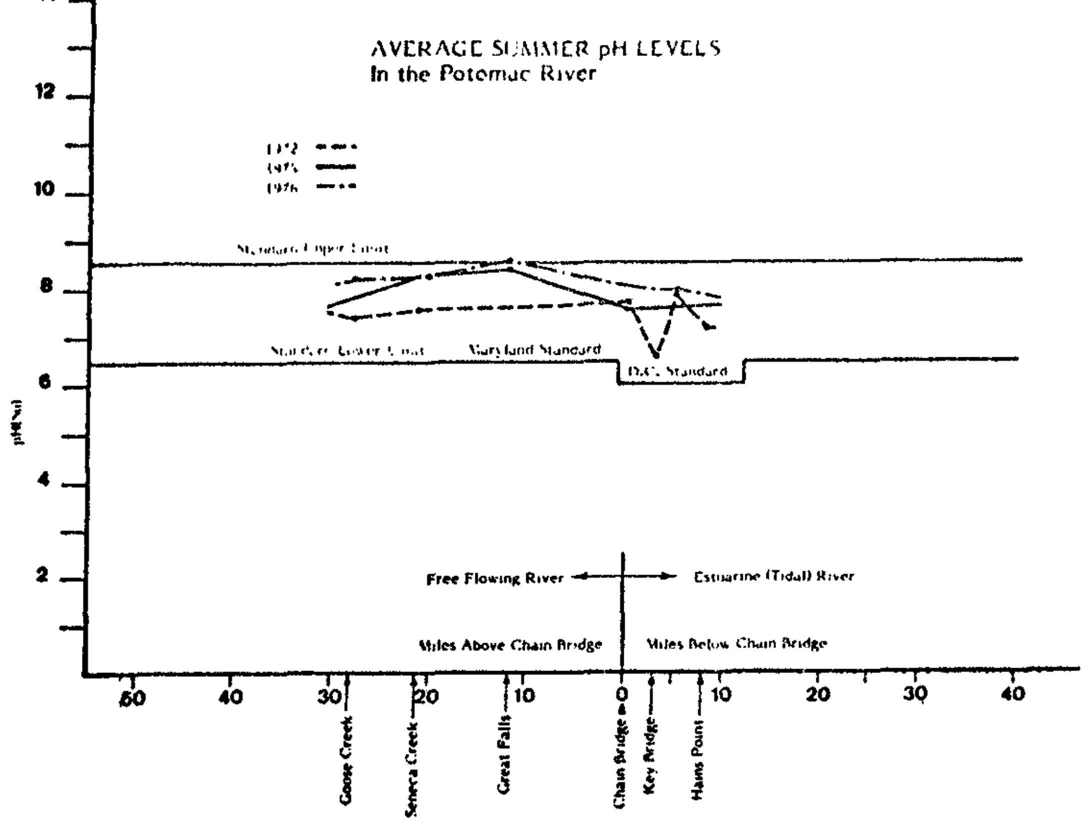
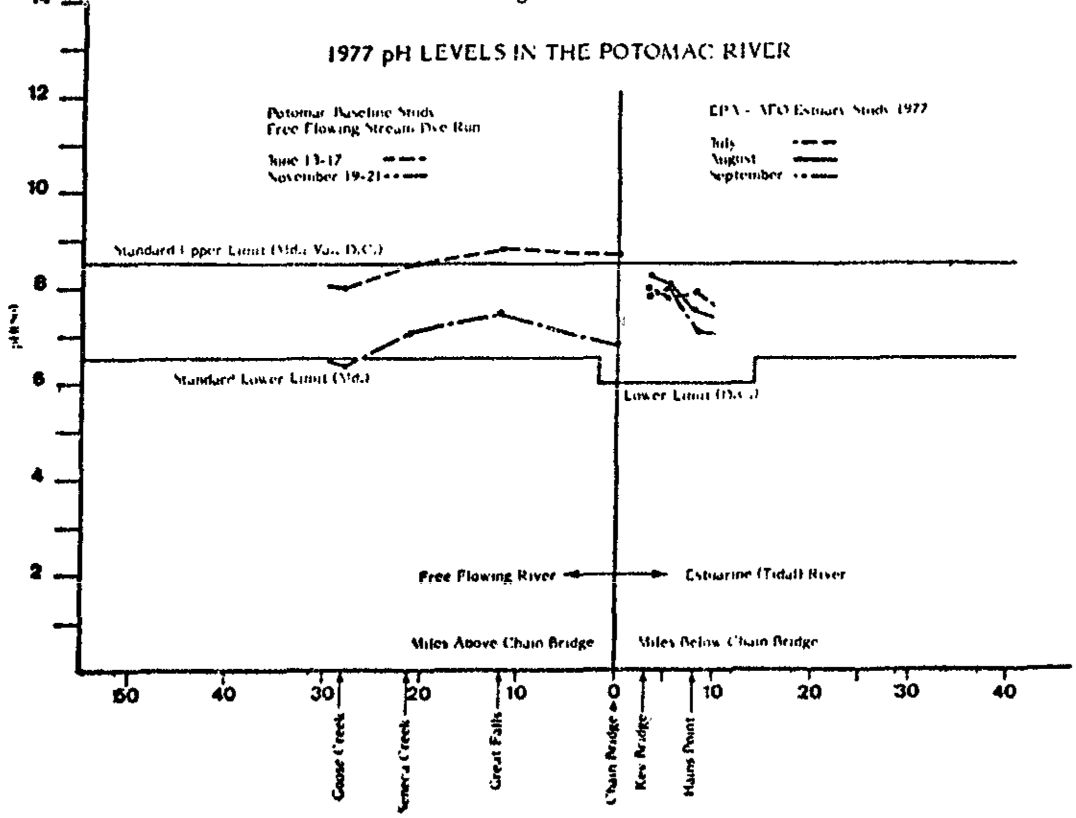


Figure 3-23



pH

pH concentrations generally stayed within the 6.0-8.5 range established by Virginia and Maryland for general aquatic life and wildlife. During 1976 and 1977 samplings, the standards were exceeded in the section between Seneca Creek and Chain Bridge, indicating alkaline conditions above 8.5 mg/l.

Temperature

The 90° F maximum state standard for general aquatic life and wildlife was not exceeded.

Suspended Solids

In 1974 average concentrations of suspended silicon-dioxide ranged from a low of 5 ppm at Seneca Creek in 1974 to a high of 26 ppm at Chain Bridge. Accordingly, water conditions appear to have met 1972 NAS/NAE criterion for total suspended solids, which estimated that aquatic communities would receive a high level of protection if maximum concentrations of suspended solids did not exceed 25 mg/l and a moderate level of protection at 80 mg/l (National Academy of Sciences, 1972).

Consideration of average suspended solids or turbidity conditions falls short of being an accurate reflection of water quality conditions for every instant of time. For example, most sampling programs are of the grab sample type collected when it is not raining, and average data will probably reflect conditions during dry weather flows. By contrast the free flowing Potomac River near Washington is subject to large, "flashy" increases in total suspended solids, especially during and after summer thunder showers and when spring rain follows the freezing and thawing of winter ground. It has been estimated that the Potomac River near Point of Rocks, Maryland transports 70 percent of its annual sediment load in 10 days of each year (McCaw and Grambell, 1977). During those periods, maximum concentrations of suspended solids probably exceed average conditions many times over.

E. Recreational Uses

From Seneca Pool to Little Falls, the Potomac River is the setting for many forms of water-related recreation. The most popular of these are fishing, aesthetic viewing and boating. Recreational activities that occur along this section of the river are discussed below. Each activity is described in relation to the areas where it occurs, the principal season of its occurrence and its general level of use (as described by Maryland Department of Natural Resources, 1979).

low - means that the recreational activity occurs to only a light extent in this river section and that there are no problems of congestion or conflicts among the participants of that particular activity resulting from the number of participants engaged in that activity.

medium - means that the recreational activity occurs to a moderate extent in this river section but that there are few if any problems of congestion or conflicts amongst the participants of that particular activity resulting from the number of participants engaged in the activity.

high - means that the recreational activity occurs at a heavy level in this river section and that problems of congestion or conflicts amongst the participants of that particular activity resulting from the number of participants engaged in that activity do, at times, occur.

Fishing: Bank fishing and small boat fishing are among the most popular forms of recreation on the river. Both take place year-round, but are less popular during the winter. Bank fishing occurs at high levels throughout the stretch from Seneca Pool to Little Falls, although concentrations generally take place at those places offering parking and access. In contrast, small boat fishing occurs at lower levels because of lack of access to navigable portions of the river. The only area where there is a high concentration of small boat fishing is Seneca Pool. The principal sport fish are smallmouth bass, largemouth bass, sucker, catfish, and sunfish, (Maryland Department of Natural Resources, 1979).

Canoeing: Both white water canoeing and flat water canoeing occur at high levels on a year-round basis, although they are less popular during winter. The most popular white water stretches are from Dam 2 at Violets Lock to Watkins Island and from Great Falls to Little Falls. Most canoeists make single day trips, but others prefer to extend the trip by camping along the river.

Since 1970, instruction in white water boating and water safety has been available on the Potomac River. The area around Angler's Inn, near Cropley, is a popular instruction site because of its variety of water types that range from slow moving deep pools to faster runs and rapids.

Flat water canoeing is popular in Seneca Pool and in the C & O Canal, but there are a few suitable stretches between Dam 2 at Violets Lock and Little Falls. Roundtrip circuits are possible for those who endeavor both white water and flat water canoeing. Roundtrips are accomplished by a combination of white water and flat water canoeing downstream in the river and returning in the canal. The number of canoeists has doubled in the last ten years. There are several large canoeing associations in the area (Department of Natural Resources, 1979).

Kayaking: Kayaking occurs at somewhat lower levels than canoeing, from Seneca Pool to Little Falls, but does take place at many of the same locations. It occurs year-round with less popularity during the winter (Department of Natural Resources, 1979).

Hunting: Hunting, allowed only in certain restricted areas along the River, occurs at high levels during the Fall. It is prohibited within the boundaries of the C & O Canal Park and at the Dierssen Waterfowl Sanctuary, but is a major activity at McKee - Beshers Wildlife Management Area and is also allowed directly in the river (Department of Natural Resources, 1979).

Aesthetic Viewing: There are several types of aesthetic viewing along the Potomac, all of which occur at high rates all year-round. Some major areas of interest are history, geology, nature study and bird watching. The study portion of the Potomac River is one of the most scenic areas in the Washington Metropolitan region.

Swimming: Swimming occurs at high levels in Seneca Pool. Downstream from Seneca, swimming may be good in places, but is generally dangerous and occurs at much lower levels of use. Summer is the principal use season (Department of Natural Resources, 1979).

High Speed Power Boating and Water Skiing: Both of these occur at high levels in Seneca Pool from late spring, through early fall (Department of Natural Resources, 1979).

F. Chesapeake and Ohio Canal Uses

The Chesapeake and Ohio Canal stretches 184.5 miles along the Potomac River from Cumberland to Washington D.C. This relic has been out of commercial use since 1924, but it is now preserved in the 20,239 acre Chesapeake and Ohio National Historical Park under the custody of the National Park Service. The lower 23 miles of the park are administered by the National Capital Parks System (Parsons, 1976). Most of this lower portion boarders the "study" stretch of the Potomac River from Seneca Pool to Little Falls.

The major park resources are the physical remains of the C & O Canal including its bed, tow path, aqueducts, culverts, locks, lock houses and other associated structures. The park has been divided into five types of land use zones. The three that are described below (Parsons, 1976) occur in the stretch from Seneca Pool to Little Falls.

Zone A: National Interpretive Zone

A designated Interpretive Zone defines areas containing major historic restoration opportunities where the park visitor is able to see a functioning canal in a historic setting. Interpretive areas are easily accessable and have available park land for development of visitor facilities. Visitor centers are expected to support large density, short term (1-2 hours) visitor use. Each of these areas represents a different setting and therefore a different theme.

Area	Setting	Length
Seneca	Industrial stone quarrying and Seneca Aqueduct	1.6 miles
Great Falls	Rural with a tavern and 6 locks	4.2 miles

Zone B: Cultural Interpretive Zone

Cultural zones define areas that contain historic resources but cannot support high density visitor use. The historic resources may spread along the canal, producing longer term visitation than Zone A (estimate 1-3 hours). Cultural zones are not necessarily completely restored for the main objective of these areas is tow path use.

Area	Length
Lock 8 to Anglers Inn	4.0 miles

Zone C: Short Term Recreational

Short Term Recreational sections are designed for the general tow path user seeking a leisurely stroll of 2 to 6 hours in a natural setting. Zone C areas are limited in historic resources and available land for visitor facilities. The sections are usually short and often link two zones of higher density. The objective is to ensure a leisurely recreational experience in a natural setting.

Area	Length
Swains Lock to Violet's Lock	5.6 miles
Alexandria Aqueduct to Lock 8	7.2 miles

Due to the narrow boundaries of the park, most facilities and activities are located on or near the canal. The major recreational activities are canoeing and fishing on the canal, use of tow path and aesthetic viewing.

In 1980, about three million people visited the portion of the park covered by this report. It is estimated that 80% of the visitors used the tow path (McMann, 1981). The tow path is primarily used for activities such as, hiking, biking, walking, horseback riding, jogging, cross country ski lessons, nature and history study and aesthetic viewing.

The portion of the C & O Canal between Violets Lock and Georgetown was rewatered in the late 1930's and since then has served as a major recreational resource. Several forms of water recreation, such as canoeing, fishing and Canal clipper rides have become popular in recent years. Each of these activities will be described below.

Fishing: Bank fishing is popular all year-round, except when the canal is frozen. Concentrations usually occur at places offering parking and access. It is estimated that about 10,000 fishermen use the canal each year (McMann, 1981).

Canoeing: Flat water canoeing has become a major activity on the canal all year round, but is restricted during the winter when the water in the canal is frozen. Users include both canoe clubs and individual canoeists. In 1980, about 7,500 people participated in canoe classes that were offered by the Canoe Cruisers Association (McMann, 1981). The total number of canoeists using the canal each year is estimated to be 20,000 (McMann, 1981).

Canal Clipper Rides: During late spring, summer and early fall, Canal Clipper rides are offered on the canal in the vicinity of Great Falls. In 1980, about 20,700 people rode the Canal Clipper (McMann, 1981).

The park has been designed and developed such that many forms of aesthetic viewing are possible. Zone A areas are especially popular with those who are interested in history, whereas Zone C areas are more conducive to bird watching and nature study.

The amount of time visitors spend in the park ranges from a few hours to a few days. Most of the short term users live near the park and use it frequently. Long term users are those who spend at least one night at either the group campground or the hiker-biker site. Group camping, especially Boy Scouts, constitute the bulk of the long term users. During 1980, about 7,400 people participated in group caming at the park (McMann, 1981).

Other facilities that are offered to the visitor include; parking facilities, picnic sites, canoe rentals, boat ramps and access to the Potomac River.